



The INSPIRE Journal

Volume 7

Number 2

April 1999

New Features in This Issue!

In addition to the usual reports on VLF observations, announcements of future observing schedules and articles by INSPIRE participants, Volume 7 Number 2 of *The INSPIRE Journal* includes several new features that will become part of future editions.

The INSPIRE Archive

Special articles from the past will be reprinted so newer members of INSPIRE can enjoy them. This issue features an article written by one of the cofounders of INSPIRE, Michael Mideke. "A Beginner's Guide to Natural Radio Phenomena" (Page 24 et seq.) originally was included with the first RS4 receiver kits delivered in late 1991. Michael is one of the most dedicated and experienced natural VLF observers and this article features a wealth of his valuable insight. The article is reprinted exactly as it first appeared, so it must be noted that some of the events that are referred to as "in the future" (INSPIRE's participation in the SEPAC experiments carried out on STS-45 in the spring of 1992, for example), have already occurred. In addition, some of the reference materials may be out of date or in other forms by now. The science in the article is excellent. Enjoy!

The Radio Jove Project

Soon the Radio Jove receiver kit will be available. More information on this project and how you can get involved is included in the article on Page 8.

Looking Back on INTMINS

The first installment of this retrospective look at INTMINS appears on Page 10. All participants in INTMINS are encouraged to contribute their thoughts to future articles.

Table of Contents

Miscellaneous Notes	3
INTMINS-April/99 Operations Schedule	5
By Bill Taylor, Washington, DC Stas Klimov, Moscow, RUSSIA Bill Pine, Ontario, CA	
Coordinated Observation Schedule - November/98	7
By Bill Pine, Ontario, CA	
An Introduction to Radio Jove	8
By Jim Thiemann, Greenbelt, MD Chuck Higgins, Greenbelt, MD	
Looking Back on INTMINS...	10
By Dean Knight, Sonoma, CA Jack Lamb, Belton, TX Bill Pine, Ontario, CA	
Hessdalen's Light Report	12
By Flavio Gori, INSPIRE European Coordinator, Florence, ITALY	
An Example of Data Analysis on a PC	15
By Robert Bennett, Las Cruces, NM	
A Beginner's Guide to Natural Radio Phenomena (An INSPIRE Archive Article)	24
By Michael Mideke, Ragged Point, CA	
INTMINS Observers - Roster Update	44
Leonid Meteor Shower - Observations and Data	46
INTMINS - November/98 Data Analysis Report	52
Report on Coordinated Observations 4/98	80
Notes From the Field	93
By Bill Pine, Ontario, CA	
Data Log Cover Sheet and Data Sheet	104
INSPIRE Order Form	106
Radio Jove Inquiry Form	107

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The INSPIRE Journal is a publication of The INSPIRE Project, Inc., a nonprofit educational/scientific corporation of the State of California. The purpose of the INSPIRE Project, Inc., is to promote and support the involvement of students in space science research. All officers and directors of the corporation serve as volunteers with no financial compensation. The INSPIRE Project, Inc., has received both federal and state tax-exempt status (FEIN 95-4418628). The *Journal* is published two times per year: November 1 and April 1. Submission deadlines: October 1 and March 1

Contributions to the *Journal* may be sent to:

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Radio Jove Note

An article called "An Introduction to Radio Jove" appears on Page 8 of this issue. This is a follow-up to the article "Radio Jove Science Education Project" which appeared in the last issue of the *Journal*. The current article contains more details about Jupiter radio astronomy and the Radio Jove receiver kit. Radio Jove has received funding through a NASA grant and, as a feature of the grant proposal, the project is aimed at schools. Since there is no provision for involvement of individuals not connected with a school in the basic grant, INSPIRE has contracted for the production of some extra kits to be made available to those who might not otherwise qualify. The kits sold by Radio Jove will have the costs partly subsidized by the grant; those sold by INSPIRE will be priced higher since the cost is not supported by the grant. The unsubsidized price is expected to be about \$100-\$120; the subsidized price will be about \$50 and will only be available to the first 100 schools that apply.

MIR Status: An Update

The status of the MIR Space Station has been the subject of much speculation over the past several months. At one time it was announced that MIR would be returned to the atmosphere to burn up as early as this spring. The Russian Space Agency would like to keep MIR in operation into the future, but lack of funding makes this unlikely. The cost to maintain MIR in operation and manned for the next three years was estimated at \$250 million. At one time an anonymous donor was reported to be ready to provide the funds, but that source of funding has failed to materialize. The United States is said to be pressing the Russians to retire MIR and apply their resources to the International Space Station. MIR is now in its 13th year of a 5-year planned life. There have been some well publicized problems in the past couple of years, but the establishment and maintenance of a constantly manned presence in space by the Russians is a scientific and technological achievement of which they are justly proud. During all of this time of triumph and turmoil, the Russian Space Agency has provided INSPIRE with an opportunity to do some space science from the surface of Earth by providing the instrument for the INTMINS observations for the past 4 years. At this point it looks like MIR will come down some time in late summer unless the necessary funding is found. It will be a sad time, but looking forward to future cooperation among the space programs of the world should provide the proper perspective to the event: MIR is a pioneer and has served us all well.

Larry Kramer's URL

The last issue of the *Journal* featured Larry Kramer's (Team 19) website. A small omission was that the URL was not included in the description. It is:

<http://home.pon.net/785/>

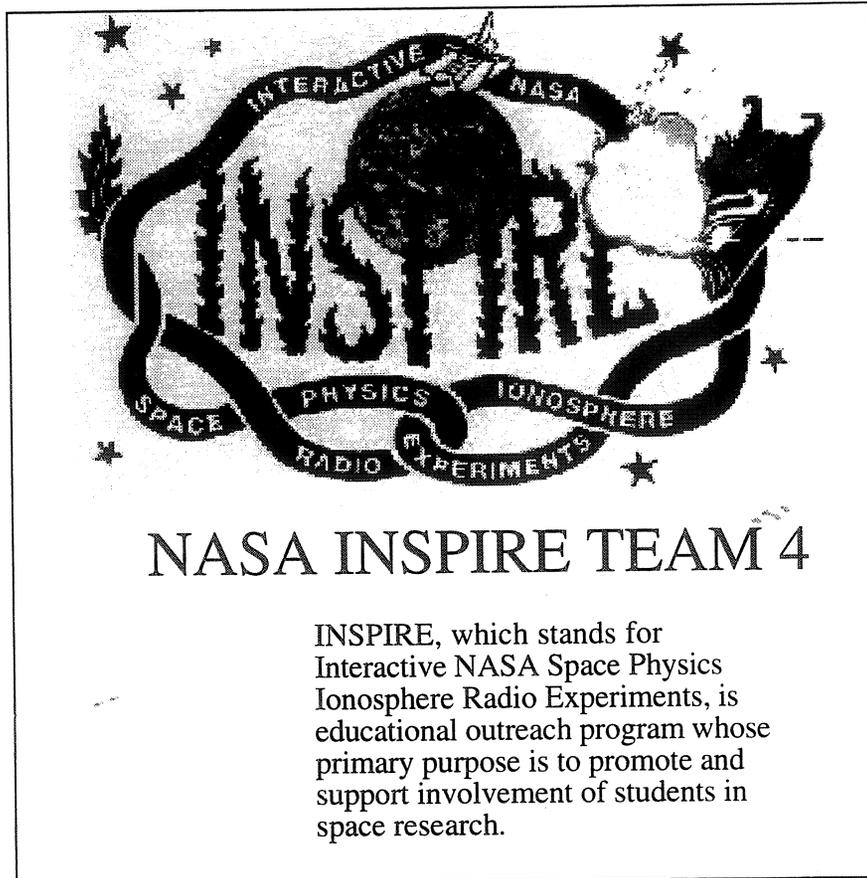
Looking Back on INTMINS...

The article on Page 10 consists of the responses of three INSPIRE participants to an invitation to write on the topic "Looking Back on INTMINS...". All INSPIRE participants are encouraged to submit their thoughts on this topic for publication in future issues of the *Journal*.

Mike Aiello's Website:

<http://www.marymt.edu/~aiello/vlf.html>

The featured website for this issue of the *Journal* is Mike Aiello's site. Mike's site starts with the INSPIRE logo and goes on to describe INSPIRE and Mike's participation.



The site includes a map of Mike's observing site overlooking the Hudson River in New York.

Also included is a link to download Mike's ATM time marking software.

Download ATM - Audio Time Marker Software

Check out some freeware that I have written to automate the job of placing time marker announcements on data tapes.

Mike's site concludes with a nice set of links to other VLF-related and space-related sites.

INTMINS-April/99 Operations Schedule

By Bill Taylor, Washington, DC
Stas Klimov, Moscow, Russia
Bill Pine, Ontario, CA

The April/99 INTMINS Operations schedule will be finalized soon. Operations will occur on the last two weekends: April 17-18 and April 24-25. Data gathered will be analyzed and reported on in the November 1999 issue of *The INSPIRE Journal*.

Gathering Data:

IMPORTANT NOTE: Data gathering procedures will remain the same as those used since April 1996.

Perhaps the most important ingredient in a successful data gathering session is what happens **before** you go out in the field. The following is the recommended procedure for data gathering including preparation prior to the date of the operation.

- Step 0: Completely check out all equipment. A good method is to set up everything in your living room. All you will hear is household 60 Hz, but you will know the equipment is working. This is also a good time to fill out the log cover sheet (see Page 104 of the *Journal*).
- Step 1: Define "T-time" as the starting time for operation of ISTOCHNIK. Convert the UT time to local time. Arrive at your site with time to spare.
- Step 2: Start data recording at T minus 12 minutes. Prior to this time place a brief voice introduction on the tape identifying the observers and the operation number.
- Step 3: Place time marks on the tape at: T-12, T-10, T-5, T, T+3, T+8, T+13, and near the end of the tape. Use UTC times only. Note that this schedule brackets the scheduled time of operation of ISTOCHNIK with time marks. Use 60 minute tapes and place one operation per side.
- Step 4: Keep a written log (see Page 105 of the *Journal*) of time marks and descriptions of everything you hear.
- Step 5: Review your tapes and revise your logs if necessary.
- Step 6: Mail your tapes and logs to Bill Pine at the address shown on Page 2. Your tapes will be returned to you. Send in copies of your logs since they will not be returned. You will receive a copy of the spectrograms made from your data. Your data will be incorporated in the data analysis report article in the *Journal*.

Mode of Operation:

The two instruments on MIR are Ariel and ISTOCHNIK. Ariel is a plasma generator and operates for 5 minutes, alternating between axes. ISTOCHNIK is a modulated electron gun that accelerates a beam of electrons and emits them into space. The electron beam is turned on and off at frequencies of either 10 hertz or 1000 hertz (1 kHz), which should cause the radiation of electromagnetic waves in the VLF range at those two frequencies. ISTOCHNIK operates for a total of 2 minutes on the following schedule:

ISTOCHNIK mode:	10 seconds modulate at 10 Hz
	10 seconds modulate at 1000 Hz
	10 seconds modulate at 10 Hz
	10 seconds modulate at 1000 Hz
	repeat for 2 minutes of operation

On each pass, Ariel will either operate first or last, whichever gives the most coverage over INTMINS observers. Since the signal from ISTOCHNIK is more powerful, it is the one most likely to be detected. For that reason, the schedule emphasizes the operation of ISTOCHNIK.

Notes on Time Marks and Logging;

The purpose of putting time marks on the data tapes is twofold:

1. The obvious need to know what time is represented in each part of the tape.
2. also to provide a means of synchronizing the tape with actual time. Battery operated recorders tend to run slower as the batteries wear out. Some recorders run fast or slow because of the particular motor being used. By timing (with a stopwatch) the actual times between time marks, the speed of the analysis recorder can be adjusted to synchronize the data tape with actual time. This has the effect of adjusting the frequencies on the spectrogram to the proper values since incorrect tape speed on the data recorder will cause the frequencies to be out of position.

When time marks are put on the tape, they should include an announcement of the UT time and a mark (either by voice ("mark") or by WWV tone or some other means). Try to minimize the interruption to the data flow when putting on the time marks. This takes practice! Also, put the time marks on at least as often as is called for by the instructions. It is better to have more time marks than are called for than to have too few.

The purpose of the data log is to record the contents of the tape. The time of each time mark should be recorded. Anything else of interest should be noted on the log with the time indicated.

Tapes with incomplete or missing time marks and poor logs are nearly impossible to analyze. Your help in following good time mark and logging procedures is much appreciated.

INTMINS Schedule

The operation schedule had not been determined by press time. The schedule will be printed separately and mailed included with the *Journal* .

Coordinated Observation Schedule April/99

By Bill Pine Ontario, CA

In response to requests in the INSPIRE Survey for observation opportunities at more convenient times, the INSPIRE Coordinated Observation Program was established in April/98 in conjunction with the INTMINS observations. The purpose of the coordinated observations is to provide an opportunity for INSPIRE observers to make recordings of natural VLF radio and to compare the resulting data. Ideally, a coordinated session would result in everyone hearing whistlers. Unfortunately, coordinated observations in November revealed mostly quiet natural VLF conditions. (See "Report on Coordinated Observations 11/98" Page 79 in this issue of *The INSPIRE Journal* .)

The procedure to use for coordinated observations will be as follows:

1. Use the Data Cover Sheet and Data Log as with the INTMINS observations.
2. Record for 12 minutes at the start of each hour that you can monitor on the specified days. Keep a detailed log of all signals that you hear and indicate any items of interest. When you submit your tapes, spectrograms will be made of any parts of the tape that you indicate.
3. Place a time mark on the tape on the hour and each two minutes for the next 12 minutes. Use Coordinated Universal Time (UTC) for all time marks.
4. Record at 8 AM and 9 AM LOCAL time.
5. In addition, record on other hours to compare results with those in neighboring time zones. For example, an observer in the Central Time Zone might record at 7 AM (8 AM EDT), at 8 and 9 AM CDT and at 10 AM (9 AM MDT).
6. Use 60 minute tapes (30 minutes per side) with two sessions per side. It is preferred that you record on one side of the audio tape only.
7. Label all tapes and logs to indicate the sessions monitored and send to:

Bill Pine
Chaffey High School
1245 N. Euclid Avenue
Ontario, CA 91762

8. Your tapes will be returned with spectrograms of your data. An article reporting on the results will appear in the next *Journal* .
9. SPECIAL NOTE: If you are hearing whistlers, replace the data tape after 12 minutes with a "Whistler" tape and continue recording with time marks every two minutes. If we get whistlers, this would be a good opportunity to try to determine the "footprint" of a whistler (the "footprint" is the geographical area where a whistler can be detected).

Specified Coordinated Observation Dates for November/98:

Saturday, April 24 and Sunday, April 25

An Introduction to Radio Jove

By: Jim Thiemann
Chuck Higgins
Goddard Space Flight Center
Greenbelt, Maryland

What is Radio JOVE?

Radio JOVE (<http://radiojove.gsfc.nasa.gov/>) is an educational project intended to get students involved in science by encouraging them to listen to a radio. Not only would they listen, but they would also help to build the equipment and use it to listen to the unique radio sounds of both Jupiter and the Sun, and possibly collaborate in research on the solar system. Jupiter generates natural radio emissions and these emissions have been observed by dedicated ground-based radio telescopes since the 1950's. The Sun is also a strong natural radio source. Strange and exciting phenomena such as predictable radio noise storms dependent on the rotation of Jupiter and the orbital position of its moon, Io, are still not well understood. Several spacecraft have monitored these radio emissions, such as Voyager, Ulysses, and Wind and now Galileo is in orbit around Jupiter, returning important new information. Solar radio bursts, however, are not predictable, but have been correlated with high sunspot activity. We are approaching the years of maximum solar activity (2000-2001) and associated radio bursts should be more frequent.

In mid to late 1999 scientists and observers around the world will collaborate as a part of International Jupiter Watch (IJW - <http://www-ssc.igpp.ucla.edu/IJW/>) and monitor Jupiter closely as Galileo crosses the orbit of Io several times. Ground-based observations are important at wavelengths not observable by Galileo and give a different perspective on the sources. Widely scattered observations help to overcome the variable filtering effects of the Earth's ionosphere. Thus students using simple, inexpensive radio receivers can participate in the scientific process by collecting, comparing, sharing, and analyzing data. Radio observations of Jupiter must be made at night when the Sun's effects on the Earth's ionosphere fade away, but the equipment can also be used for daytime observations of solar radio phenomena.

The project will adopt the successful approach used by the Interactive NASA Space Physics Ionosphere Radio Experiments (INSPIRE - <http://image.gsfc.nasa.gov/poetry/inspire>) program for involving students in ionospheric observations through the building of special Very Low Frequency (VLF) receiver kits and making their own measurements. We hope that many of the schools that are participating in INSPIRE will expand their activities to this new area.

What are the program objectives?

- 1) To acquaint students with the science of radio astronomy and the excitement of being involved in the scientific process.
- 2) To learn electronics through construction of inexpensive kit-based radio receivers suitable for hands-on learning of radio astronomy as a science curriculum support activity.
- 3) To collaborate with other schools and the science community through a web site that teaches about radio astronomy and is a coordination point for Radio JOVE data sharing in conjunction with the International Jupiter Watch program.
- 4) To enable, through the World Wide Web, observation and usage of data from a professional radio telescope observing Jupiter and the Sun.
- 5) To develop educational resources for teaching and understanding the science of radio astronomy.

How does it work?

The Radio JOVE project is centered around the development of low cost radio receiver/antenna kits which can be assembled by science classes and used to collect planetary or solar radio astronomy data. It is intended for high school level classes, but may be appropriate for college or even middle school levels. The students build the kit using basic electronic tools under the supervision of the teacher. They also construct the special antenna needed to receive the planetary or solar emissions. The antenna requires construction of a basic structure using wood or pipe, ropes, stakes, etc.

Once the kit is completely assembled and tested the students determine a good time to observe Jupiter based on predictions supplied on the Radio JOVE website. Note that Jupiter radio signals can only be received at night and the conditions are often best in the hours just before dawn. Also, the antenna needs to be set up in a location that is as free from electrical interference as possible. This may be possible near some schools, but it is recommended that observing be done in nighttime field trips to locations away from power lines and other sources of interference. If nighttime viewing or field trips are a problem, daytime viewing of the Sun at an outdoor location near the school may provide the equivalent observing experience.

The kits cost approximately \$100. The kit contains:

- 1) All parts for the JOVE receiver and a few tools (other tools are required);
- 2) Complete step-by-step instructions for assembly;
- 3) Antenna parts including cable, wire, and connectors;
- 4) Complete step-by-step instructions for antenna assembly and setup;
- 5) CD ROM with chart recorder software and general information;

Discounts will be offered on the first 100 kits ordered by schools. The materials for supporting the antenna are not included in the kit nor are the tools that are necessary to put the kit together, such as a soldering iron, wire clippers, and other typical tools for putting together electrical kits. Many schools may have these materials and tools already, but, if they do not, we estimate they will cost about \$60. Recommendations for these tools and materials are in the kit.

In order to be able to analyze the data and share it with others there is also the need to capture the radio data and this can be done by feeding the output of the receiver into a tape recorder or directly into a computer. On a field trip it may be more convenient to use the tape recorder than to carry along a computer, even if you have a laptop. Small tape recorders can be purchased for this purpose, but they must not have an automatic gain control (automatic volume adjustment) or the control must be capable of being switched off since such a control makes it difficult to measure the relative strength of the signals. The cost of recorders sufficient for this purpose is about \$70 (Radio Shack Models CTR 69 and CTR 117 are both priced at \$70). Software is supplied with the kit that simulates a standard professional chart recorder for plotting the data using a standard 486 or higher model personal computer. The computer will also need a sound card. The software is contained on a CD that is sent with the kit.

A central web site will accept files of data from observing groups around the country and make them available for schools and scientists to see and hear. The site also contains general information and activities relevant to the understanding of radio astronomy and, in particular, how to order, build, use, and understand the data from radio receiver kits. These web pages are currently under construction and will be fully developed by the summer of 1999.

How can my school participate?

Fill out the inquiry form on the last page of this edition of the *Journal* and send it to the indicated address. We will get back to you as soon as possible about your request and what will be done from that point.

If you are not associated with a school, you may still fill out the form. The price for the kit, when determined, will not be discounted to those not associated with schools. This is because of conditions placed on the grant support for this project. The undiscounted price will probably be between \$100 and \$120. The discounted price will be about \$50.

Looking Back on INTMINS ...

by: Dean Knight, Sonoma, CA
Jack Lamb, Belton, TX
Bill Pine, Ontario, CA

With the approach of the end of the MIR Space Station, we also approach the end of the INTMINS operations. Several participants have contributed thoughts on the value of the INTMINS operations and the future of this type of scientific investigation. Similar contributions are solicited from any other INSPIRE participants. Another article "Looking Back on INTMINS..." will be published in the next *INSPIRE Journal*.

Dean Knight, Sonoma Valley High School, Sonoma, CA

If I were to list the primary contributions of INTMINS, it would be a statement that included two parts: one for my students and one for international cooperation.

First and foremost is that for my students. The chance for the students to do real science in a relaxed, fun, exciting situation that involves a bit of hiking (both daytime and night), a bit of involvement with technical apparatus (other than a TV or computer), a bit of camaraderie (quite a bit), a bit of careful observation, a bit of new ideas (both up on the mountain-our radio site- and back in the classroom), a bit of continuity (we have been involved with this for a while, and this year we had a group of senior students who had been involved as freshmen as well as present freshmen students who had participated with their older brothers or sisters several years back), and a bit of a chance for students to claim on resumes that they have been involved in an international physics study. (There have also been a few perks for the school to be involved in such a project--actually at this point it may surprise some that this is our last year with the project as it is now configured--hard to believe!) Needless to say, I hope that every effort will be taken to continue the study in a meaningful international way.

The second part (the international cooperation one) has advantages that speak for itself. YES, I think an experiment like INTMINS should be included in the International Space Station. but I hope we don't wait until the Station is available- we need to occupy the intervening years with another project. Coordinated observations are, of course, a possibility, but I personally would like to see a project that would continue to more directly involve the Russians. I really think this is important. Maybe there is something significant that can be done. Thanks for keeping the project going.

Jack Lamb, Belton, TX

So far, I think INTMINS' contribution to science has been minimal since I am not aware of any discoveries that resulted from our work. The fact that we have worked with MIR in this study is a fine example of international cooperation in science. Perhaps it will lead to more such cooperation in the future.

My wife and I have enjoyed getting out to our quiet site to record the various operations. We wish we knew more about what we were doing, but we are happy to know we are contributing something to a project that we feel is very worthwhile. My grandson is not as excited about standing around listening to static. A few minutes is enough for him. He always brings a book to read while I stand around and listen to static. It is nice to have him there anyway in case something goes wrong.

The value of INTMINS is not entirely clear to me. It has certainly been a valuable experience for me and, hopefully, for all other participants to be part of a team that spans the globe. It is interesting to see the graphs of our data we send in. I am beginning to understand what the dark marks mean. I hope we discover something dramatic (maybe even useful) before MIR burns up in the atmosphere next year. INTMINS should certainly be included in the International Space Station so we can continue our research. Hopefully, the novelty of the new space station will attract more members for our team.

I mentioned a global team above, but have noticed, in particular, that there are no Russian observers as far as I know. I hope that will change soon. I wonder if we would benefit from observers in the southern hemisphere? Now that we are on line, perhaps we can make ourselves known to more people in the world so that they can consider joining us.

I hope there reflections on the past and wishes for the future are helpful for your retrospective article in the April, 1999 issue of *The INSPIRE Journal*.. I am looking forward to reading it.

Bill Pine, Chaffey High School, Ontario, CA

I have been involved with natural VLF radio observations for the past 10 years. I have taught physics for the past 25 years, so I am in a position to compare the physics curriculum with and without VLF radio observations. Even though the radio observations occur outside the normal school day and outside the formal physics curriculum, participation in INSPIRE activities has had a positive impact on both my students and me. INTMINS, as the latest example of INSPIRE activities, is a prime example of that positive influence. There are many good things about being involved in something like INTMINS:

1. Spending time off campus with students allows everyone to get better acquainted - both with the teacher and with each other. Lasting friendships have been forged between students who might not otherwise have even met. The times riding up the mountain and back down are very pleasant and the feeling of accomplishment after successfully meeting an operation schedule is something to be proud of.

2. Meeting a schedule like that of INTMINS is an important activity for students (and teacher). In the school system, the emphasis seems to be less on encouraging students to be responsible and more on constantly giving them second chances. With INTMINS, if the team is late, MIR does not wait! Your "second chance" may not come for another six months. Students do a pretty good job of meeting their time obligations, but when they do not, they find that the "bus" has left and they miss out. This is a good experience for them especially since the only consequence is that they miss out.

3. Finally, INTMINS has a positive impact on physics enrollment and attitude. Each year several students who might not have taken physics otherwise enroll in physics. The enthusiasm and positive attitude of the students involved in INSPIRE is a good example for other students to follow - and some of them do!

I don't know what the physics program at Chaffey High would be like without INSPIRE and INTMINS, but I strongly believe that it would not be as good.

What are your thoughts "Looking Back on INTMINS ..." ?

All INSPIRE participants are encouraged to share their thoughts to be published in future issues of *The INSPIRE Journal* .

HESSDALEN'S LIGHT REPORT

By: Flavio Gori
Florence, ITALY

In Europe there are many people involved in strange phenomena, both in optics and electromagnetic radio waves fields. Probably there are some more areas but we can talk about these two. Some would say that it is a classical way at the end of one millennium, as the end of the world and the like. While there are many of these phenomena, unfortunately we can't say that all are studied by serious researchers and scientists. This allows people to say anything they want as if personal thinking may be the reality. I understand that not always what some persons may believe, is the truth and it may not always be appropriate to give their views strong importance, but sometimes the number of persons who can supply important support is enough to propose a scientific explanation for the phenomena.

That's what happened in a valley on the Scandinavian peninsula in the southeast of Norway. The subject of our story this month is not far away from the small town of Trondheim and about 30 kilometers northwest of the town of Roros. The valley is about 2 kilometers long and, in the beginning of the reported lights, about 150 people were living there. The phenomenon, which often tended to occur at very low altitude, had been showing a large variety of displays: multicolor and multiform lights, pulsating and flashing lights, lights whose regime of motion was rapidly oscillating, fast-moving or fixed lights, lights which were turned on for over an hour, lights which were "reacting" after a laser beam was pointed toward them. Apparent dimensions of the luminous phenomenon ranged from point-like or strongly illuminated Venus-like objects to very extended Moon-like objects, and its distance was very often estimated to be 1-3 kilometers, so that, from reference points (such as trees or houses) whose distance was known, it was possible to estimate an intrinsic diameter which was ranging from 1 to 10 meters. The existence of a very large number of witnesses convinced some scientists that a serious study should be soon attempted. All this is because in the years 1981, 1983 and 1984 a luminous phenomenon appeared in the valley and was so repetitive and seen by a number of persons who were able to support their words with strong evidence, or so it was believed by scientists who went there to study the phenomenon. This led to the formation of Project Hessdalen which was a group which included Norwegian engineers and scientists constituting a "working committee", together with external consultants operating in the astrophysical and geophysical branches.

An analogous measurement campaign had been carried out at Piedmont - USA in the years 1973-1981 when a very similar phenomenon could be monitored by physical scientists. Observations in the Hessdalen area started 21 January 1984 and ended the 26 February of the same year and the following instruments were employed: seismograph, radar, EM antenna connected to a spectrum analyzer, magnetometer, laser, Geiger counter and IR viewer; moreover a grating was added to conventional cameras. All of these instruments, except for gratings, Geiger counter and IR viewer, could provide some meaningful measurements. All the instruments were installed in two stations placed inside the Hessdalen valley. Technical personnel were constantly at the sites to monitor instruments and the ongoing situation in real time.

A total of 188 sightings could be reported, of which at least 58 couldn't have an explanation in terms of known objects. About 70% of the most reliable reported luminous phenomena were moving along a north-south direction. Radar, radiometric and magnetometric measurements and laser-pointing tests showed such a peculiar behavior that couldn't be clearly explained, at that time, in terms of known laws of physics, geophysics and atmospheric physics. In particular, the laser, once pointed to some specifically pulsating objects, seemed to cause a doubling of the objects' pulsation rate. This is still now a mystery which, later, suggested physicists to investigate on possible kinds of photon-photon interaction, but, still now, no

satisfactory explanation has been furnished. Unfortunately such object reactions to the laser beam acquired only the value of a visual report. Both instrumental measurements and simple visual observations were accurately reported by "Project Hessdalen" researchers.

Twelve years later a computer analysis of the available data has been attempted in order to study the time-variability of the phenomenon in many of its aspects, including possible correlation between the different aspects of the phenomenon and finally possible correlation with daily solar activity. The character of this study can only take into account the phenomenon as a group of points in time. Such an analysis has regarded only data whose quality can allow a scientific approach. A physical analysis of every single sighted object is not possible because the obtained photographic and spectrographic data don't contain sufficient information: photographs are often of very good quality but the only possible computer analysis which is applied to them can serve to demonstrate that a given object is real but still not allow the investigation of its intrinsic nature. Obtained grating-spectra of the objects were very few and in most cases signal to noise ratio was judged too low in order to allow a consistent analysis. The study of the intrinsic nature of the objects will be, hopefully, the subject of future systematic instrumental investigations which have been already planned and partially tested and which invoke the use of up-to-date technology. Being involved in radio waves, it is obvious that my principal interest is radio related and here you will hear about the kind of radio waves research carried out in the Norwegian valley.

The following the instruments were used. As you can see, there were very good tools.

1. Hewlett-Packard spectrum analyzer
sections 8544L-RF, 8552A-IF, display 1415
operating in the range 150 kHz-1250 Mhz.
2. Singer NM-25T radio interference and EM field detector,
operating in the range 150 kHz-32 Mhz.
3. Wide-band antenna (home-made conical spiral type).

Even if the spectrum analyzer was not running all the time and even if the screen was not monitored in a continuous way, two types of recordings could still be reported:

1. A single-frequency component, whose frequency could range from 130 to 1115 Mhz and whose amplitude could range from 12.5 to 22.5 dB. The signal was characterized by a single spike whose amplitude was going up and down: this kind of signal was called "Type 1".
2. A signal characterized by several simultaneous spikes with almost equal amplitude, with 80 Mhz between each, all over the frequency band from 100 kHz to 1250 Mhz. The amplitude of the spikes was oscillating up and down: in the down phase it was about 5 dB over the noise, in the up phase it was 25-30 dB over the noise. This kind of signal was called "Type 2".

Comparing data, it is possible to notice that Type 2 signals occurred a few hours before or after the luminous phenomenon, while some of the Type 1 signals seemed about to coincide with it.

Recordings of radio events which are suspected to be related to UFOs have not been a unique prerogative of the Project Hessdalen Norwegian team. During an observational and, partly, instrumental campaign carried out in the period 1973-1980 at Piedmont (USA), physicist Harley Rutledge and his collaborators, using a spectrum analyzer could record similar spike-like radio events which were presumably associated to luminous phenomena. Anyway, even if very numerous and good estimations of distance and size of luminous phenomena could be done, the number and the quality of reported radiometric data at Piedmont were respectively much lower and worse than the ones obtained in 1984 at Hessdalen. Furthermore, astrophysicists George Smoot

and Giovanni De Amici of the Lawrence Berkeley Laboratory (USA), using a small dish for radioastronomic research, recorded accidentally and repeatedly strong unexplained radio spikes during a mission in Antarctica, which was devoted to the measurement of the 2.7° K background cosmic radiation. Unlike the Hessdalen and Piedmont cases, in this specific case no luminous phenomenon was reported about to coincide with radio-spikes. This last, was from a book written by G. Smoot and Keay Davidson in 1994 and named "Wrinkles in Times". Very interesting also to understand how these strange spots may appear and look like. This research is carried out by a Norwegian University and is headed by Dr. Erling P. Strand. One of his colleagues is Dr. Massimo Teodorani from Italy, an astrophysicist living in Cesena, a central eastern Italian town. These two researchers are the authors of the report largely quoted in this article of mine, as indicated in the footnote below. They have been working on the Hessdalen phenomenon since 1994 and are still working on it. Their new campaign will begin in few months, though the one I'm reporting on here is still in progress as data treatment.

As I reported some years ago for the Ostina phenomenon (maybe someone will remember in the 2/95 Journal), light spots in the atmosphere may be studied also by Natural Radio tools such as the WR3 as well as Inspire receivers. I wonder if Hessdalen phenomenon may be detected by very low frequency radio receivers and antenna or, better, a radio/antenna net positioned in the Valley, connected with portable computer (such as PowerBook) with FFT sonogram software (with log scale and real time feature), or Spectrum Analyzer. It should be fine to establish such a network, thinking to the phenomenon's and Valley 's geography. In the next Journal I'll try to explain what I'm planning to do. (Are there any Norwegian Inspire members?).

In my conversation with Teodorani I usually ask why there are no VLF/ULF research programs in the Hessdalen site. Being an optic researcher, he is not able to answer in detail. Maybe it would be interesting ask to Strand or someone else familiar with radio waves why this is. I'll do it as soon as I can.

This article is just the first part. The second one will be here in the next Inspire Journal.

Note.

Technical data are from:

The Hessdalen luminous phenomenon: a data analysis.

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The author thanks Massimo Teodorani for his kind permission to reproduce their work.

An Example of Data Analysis on a PC

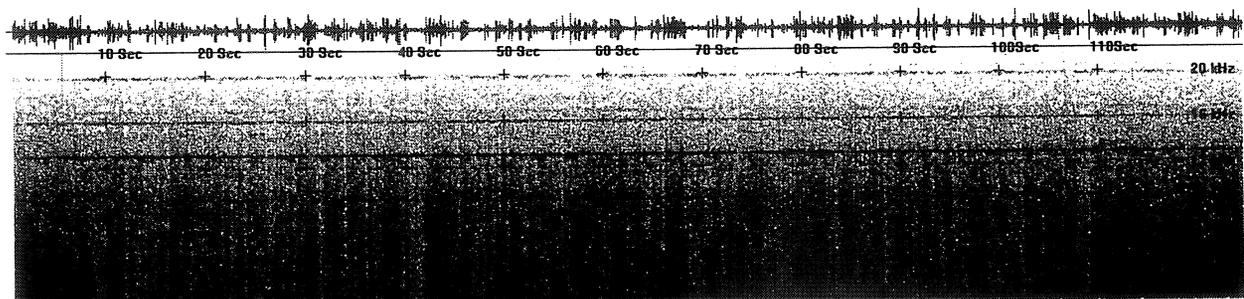
By: Robert Bennett
Las Cruces, New Mexico

(Editor's note: The following was not originally submitted as an article, but rather as a communication to the data analyst. The analysis was so well done that it seems appropriate to make a full-fledged article out of Bob's work.)

As far as the mechanics of monitoring, everything went well with only a few minor problems. The weather even cooperated, it was warmer than normal this time of year in southern New Mexico, the ground was still a little wet from rains during the previous weeks and this helped prevent blowing dust, a constant problem for me normally. I had a cable connector fail on one mission (I had a spare), and ran down the batteries in all three of my flashlights during one evening (the result of buying discounted batteries that were alleged to be fresh).

Attached to this note are my logs for the Nov. 98 monitoring sessions. (See Pages 20-23 for sample copies of logs.) I have also sent in my audio recordings and two Iomega ZIP Disks with the results of my reduction of the audio recordings

The wave and spectrogram files on the disk can be decoded as follows. Each file starts with the mission number and the extension gives the type file. For example, 22-2.WAV is the audio recorded during the two minute of the ISTOCHNIK Mission. The resulting spectrogram for the entire two minutes is file 22-2.BMP. The spectrogram of the first 30 seconds or so of this period will have an "A" appended in the file name, e.g. 22-2A.BMP. Other items on the tape that were of interest to me are recorded with an "X" in the file name (for example 22-2x1.wav is file from an antenna test.

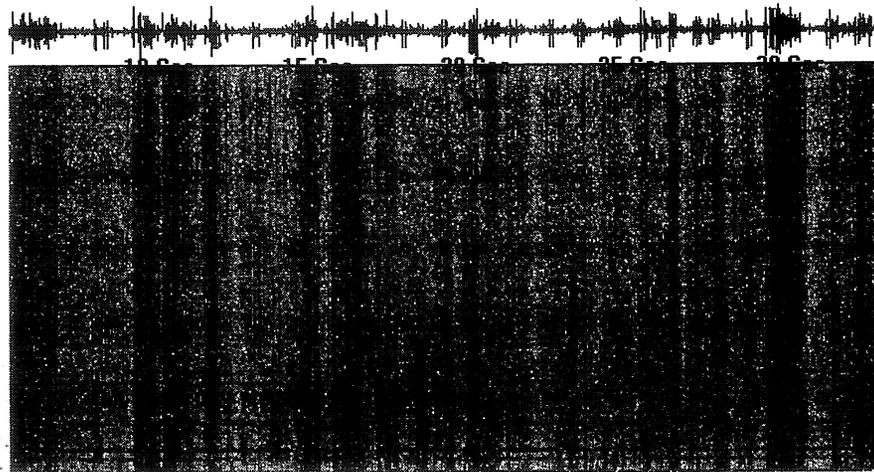


File 21-2.BMP Operation 21-2. On the GRAM display screen, at the top is the waveform graph and below is the frequency-time plot. Time is shown across the top of the spectrogram; frequency is shown to the right. There is a grid mark (+) at each 4 kHz and 10 seconds.

I recorded missions 21-2, 21-3, 21-4, 28-9, 29-1, 29-2, 29-3, and 29-4. I was not able to monitor during the coordinated monitoring periods on 29 November because of rain. In general,

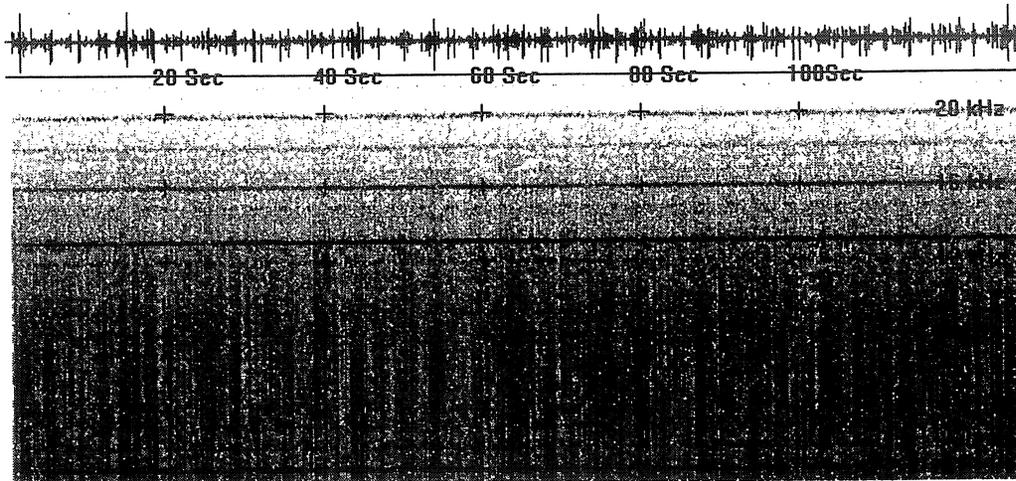
I found the November monitoring sessions to provide some of the highest intensity activity I have seen in natural radio signal monitoring. The spheric levels were always high, I estimate between 8 and 10 on a scale of 1 to 10. The tweeks were frequent and intense, almost always having a chirp tail on them. I thought I recorded one weak whistler; however, I could not find it on the spectrogram after processing.

I did not detect the ISTOCHNIK signal during these observations. This is not a surprise since one look at the spectrograms tells why. I have a LORAN Station about 40 miles from my monitoring location. The Loran pulses produce spectral components (or lines) right on top of the ISTOCHNIK frequency of 1 kHz. The Loran component is much stronger than I would expect the Inspire signal to be.

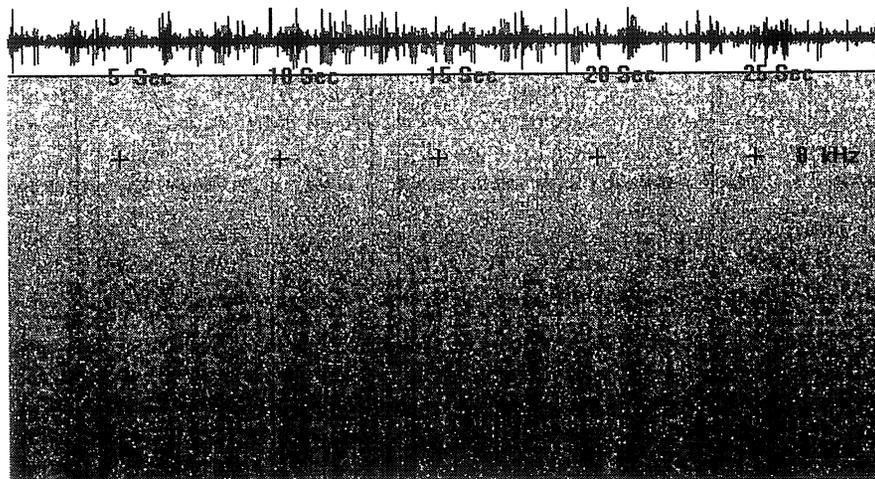


File 21-2A.BMP Approximately the first 30 seconds using 0-5 kHz frequency range. The horizontal rows of dashes are from the LORAN station. Notice the row of dashes at 1 kHz.

I noticed several interesting things. First, the 60 cycle hum levels varied quite a bit on me. The recordings on 21 November had no evidence of hum. The recordings on the rest of the days had some minor hum present. Also, during recording on 28 November, I noticed what seems to be varying levels of hum, amplitude would seem to increase for several seconds then decrease. The random noise level (hiss on the tape) increased as the nights wore on. The recordings made early in the evening show lower levels than those made late at night. The increase seems to be most noticeable in the 4-8 kHz band. I included a spectrogram of the increased levels on the Zip disk (files 22-3x1.BMP, 22-3x2.BMP and 22-3x3.BMP).

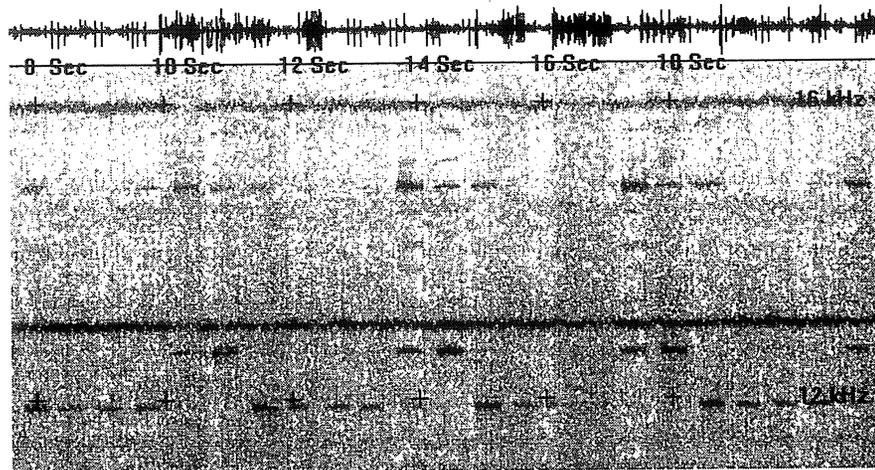


File 22-3x2.BMP Hum shows up as horizontal bands below 8 kHz.



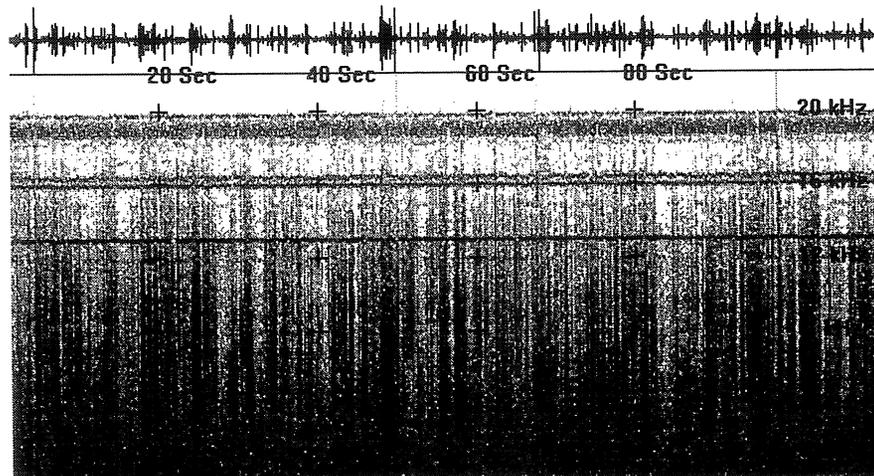
File 22-3x3.BMP Closeup of 4-8 kHz band showing hum.

I recorded the Russian Alpha system during every session. I enclosed a good example of a spectrogram showing the structure of these signals (file 21-2b.BMP).



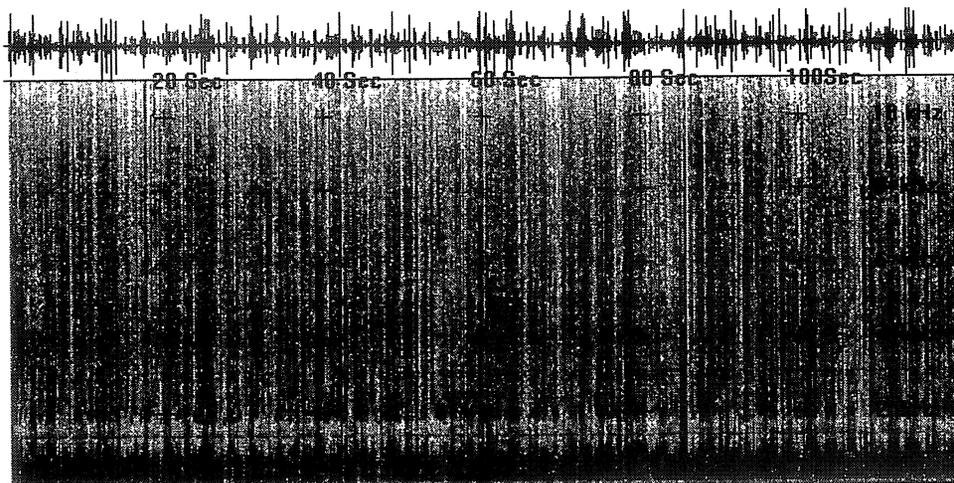
File 21-2b.BMP Dashes are from Russian Alpha navigation stations. There are three stations transmitting patterns of dashes at frequencies between between 11.905 kHz (the lowest row of dashes) and 14.881 kHz.

I found communications signals at 13.1, 16.0, 19.8, and 21.4 kHz.

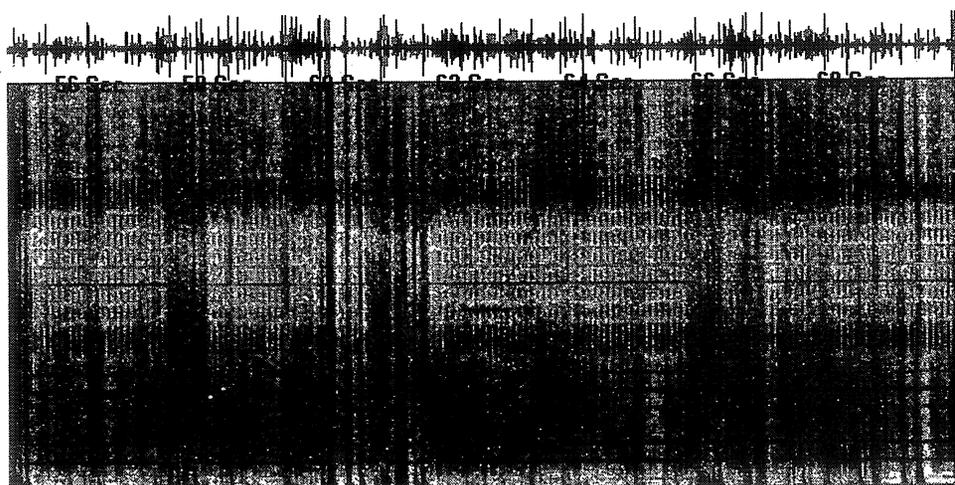


File 28-9.BMP Horizontal lines indicate communications signals at several frequencies above 12 kHz. A cursor function included in the GRAM software allows precise determination of times and frequencies.

Also, on 29 November, I noticed two steady signals at 1384 and 1503 Hz. The signals were not present in all the recordings and I am not sure what they are.



File 29-1.BMP



File 29-1A.BMP Horizontal lines show the steady signals.

Finally, I conducted several antenna experiments during these sessions. Details can be found in my hand written logs and sample spectrograms are included on the Zip disk.

(Note: The following pages show copies of Bob's logs for Operation 22-2 including his antenna tests.)

DATA LOG COVER SHEET
OBSERVER: Robert Bennett
DATE: 22 NOV 98

OPERATIONS DETAILS

Type Operation: ISTOCHNIK 22-2

Tape Start Time: <u>0252</u> UTC	Local Time <u>1952</u> MT.
Operation Start Time: <u>0304</u> UTC → <u>0302</u>	Local Time: <u>2004</u> MST, Sat. 21 Nov 98.
Operation Stop Time: <u>0306</u> UTC → <u>0304</u>	Local Time <u>2006</u>
Tape Stop Time: <u>0317</u> UTC	Local Time <u>2017</u>

T-Time Correction = -2 min

EQUIPMENT

Receiver: VLF-2
Recorder: Marantz CP 430.
Antenna: Several used
see next
page.

WWV Receiver: Yupiteru MVT 7100
WWV Antenna: 10' whip
WWV Frequency: 5.00 MHZ.

Misc: limiter on recorder was "on" to prevent recorder meter damage

SITE INFORMATION

Location: 32 deg, 34 min N LAT: 106 deg, 41 min W LON: Elevation: 4290 Feet

Site Description: Desert valley between two mountain ranges.

Temp: 34 F. R.H. 66 %.

Local Weather: No wind, no rain in about a week but
ground still has moisture in it, dew point occurred
in this mission, every thing has water film on it.

Name and Address: Robert Bennett

Las Cruces, NM 88012

22 NOV 98

Antenna Experiments.

During this mission, I experimented with ~~two~~ ^{four} different antennas.

ant-1

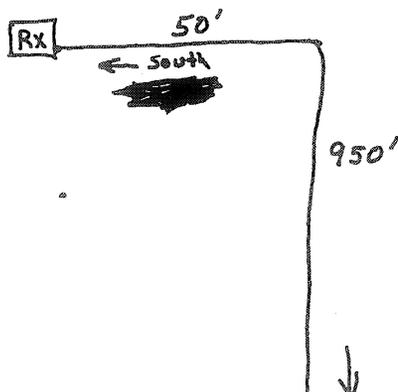
6' vertical whip mounted on a fence post. The bottom of the whip is about 5' above ground.

ant-2

120 Ft Long wire. Feed end is about 3' above ground and distant end is about 20' above ground. Orientation is North-South.

ant-3

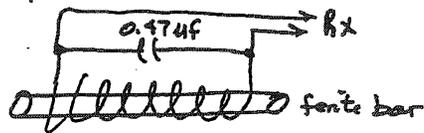
1000' surface mounted insulated wire. The wire was deployed in an "L" configuration and was laid along the dirt trail used to access my monitoring site.



22 Nov 98

ant-4

Ferrite loop antenna tuned to 1.0 kHz.



The Loop was orientated N-S and was mounted on a 2' high PVC pipe.

General observations.

The recording level meters on the Marantz gives an integrated or average signal level in DB. The following were observed during the testing:

Antenna	recorder level in DB
#1 120' LW	0 to -2 db
#2 6' whip	-2 to -4 db
#3 1000' LW	steady at about -4db
#4 Ferrite loop	-20 db
1+2+3 sum	0 to -2 db

The best signal level seems to be provided by the 120' LW, followed by the 6' whip. The others are worse.

Date: 22 Nov 98

APE RECORDER COUNTER	TIME UT	EVENT	SFERIC LEVEL	COMMENTS
0-10		Voice Announcement		
10-28		level adjustments	9	
30	0246	WWV		<u>ON 120' L.W. Ant</u>
68	0248	WWV		lot of strong tweaks
103	0250	WWV		60 n present but weak
107-109		Antenna change to 6' whip		<u>6' Whip Ant</u>
			8	60 n hum has on.
				6' Ant.
134	0252	WWV Suggest Tape start		Loran about same
164	0254	WWV		
178	0255	WWV		
179		antenna change to 1000' L.W.	6	Loran stronger.
192	0256	WWV		Sferics lower?
		The tweaks seem to "ring" more on the 1000' L.W.		
218	0258	WWV		<u>1000' L.W.</u>
243	0300	WWV		
245-251		Change back to 120' L.W. for mission		
268	0302	WWV <u>Corrected T-Time</u>	9	<u>120' L.W.</u>
291	0304	WWV <u>T-Time</u>		60 n hum seems to
313	0306	WWV <u>mission End</u>		have decreased.
335	0308	WWV		
341-347		Change Antenna #1 + #2 + #3		<u>Combined Antennas</u>
356	0310	WWV		The 1000' L.W. seems to
				Act as a filter to remove
376	0312	WWV		Some Natural Radio Signals
396	0314	WWV		
397		Change Ant to Ferrite Loop		<u>#4 Loop Ant</u>
406		End of Recording and Tape		<u>almost No Signal</u>

A BEGINNER'S GUIDE TO NATURAL VLF RADIO PHENOMENA

How to Hear and Record Them

By Michael Mideke
Ragged Point, CA

The emergence of new technologies has a way of revealing unexpected aspects of the natural universe. The telephone, which effectively shrank our world by superimposing its electronic dimension upon our existing physical space, has played a coincidental role in showing us the same world larger, more mysterious, more wonder-filled than we'd imagined.

The story goes back to the earliest long telephone lines, clear back to the 1880s and operators who reported strange chirps and whistles that had no obvious connection with the telephone system and its traffic. It was a mystery, but one which attracted little serious attention until much later, when it emerged to complicate life in the entrenched battle-fields of World War I Europe.

Though primitive by today's standards, there was a mature telephone technology when the war began, and that technology soon found its way into the trenches. Electronic Counter Measures arrived immediately thereafter in the form of high-gain vacuum tube amplifiers which each side employed to intercept "leakage" from the other's communications. The general idea was to run wires from widely separated ground stakes to the input of a sensitive amplifier sampling stray or induced currents from the enemy's telephone system. For the most part, this worked well enough to be worth the trouble but now and then eerie descending whistling tones appeared in the monitors' headphones. Some likened them to the sound of phantom shells passing over-head. At times the cacophony of these "whistlers" became so thick that eavesdropping efforts were completely foiled.

The German scientist H. Barkhausen became quite intrigued with these peculiar sounds. His initial assumption was that they were an artifact of the amplifiers, but his attempts to reproduce the whistler

phenomenon in the laboratory were fruitless. About this time he did make basic discoveries relating to electronic oscillators. and it is interesting to speculate that his pursuit of whistlers may have played this. Barkhausen's next conclusion about whistlers was that they were a natural phenomenon which could not be explained on the basis of current knowledge. It was a fascinating puzzle, and over the years he and other researchers pecked away at it, arriving by late 1920s at fairly general agreement that lightning was responsible. A correct interpretation, but the "how" of it remained elusive until the 1950s.

What does the sudden flash and roar of lightning have to do with these musical electromagnetic signals that glide from as high as 30 kHz down to less than 1000 Hz? How can the one event lead to the other? The key lies in the nature of electrical sparks.

Lightning is a spark discharge - a huge spark, embodying peak currents of thousands of amperes, potentials on the order of 250 million volts. Any electrical spark is a source of electromagnetic energy. Not only light but ultraviolet, infrared and radio. The latter is the basis of Heinrich Hertz's experimental verification of Maxwell's equations, and the source of whistlers.

Rather than being a coherent signal confined to a particular frequency or band of frequencies, lightning's radio emission is a broad spectrum burst - all frequencies appear in it at once, from hundreds of Hz through hundreds of MHz. On our conventional AM and short-wave radios we hear these bursts as the snap and crackle of static. Were you to line up several radios tuned to different frequencies, chances are good they would all register the same static bursts at the same time. (The experiment is not guaranteed to produce this result because radio waves propagate quite differently at different frequencies - radios - tuned to widely separate

parts of the spectrum might be responding to static from completely different areas of the world.)

A large percentage of lightning's effective radio energy is concentrated in the 1 to 30 kHz region loosely defined as the VLF or Very Low Frequency region. (See Figure

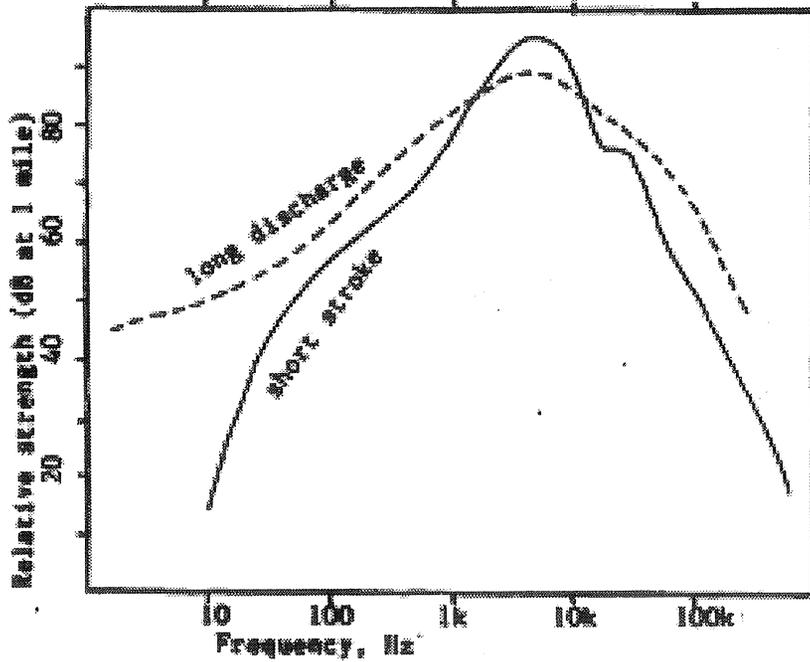
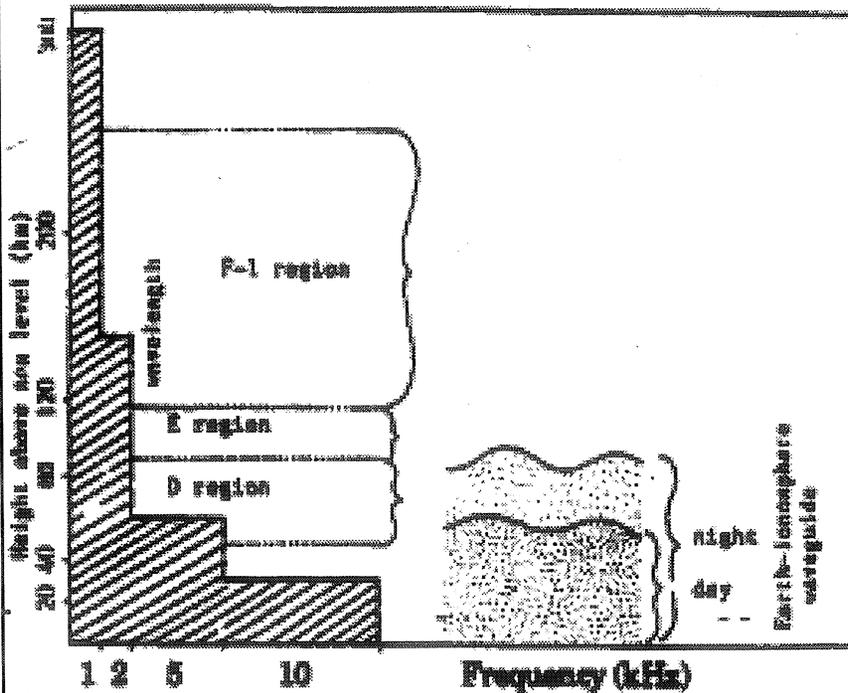


Figure 1. Lightning's radio energy in the ELF-VLF region. After Watt, VLF RADIO ENGINEERING

Figure 2. Frequency vs. wavelength, seen in the perspective of ionospheric regions. Signals whose wavelength exceeds twice the waveguide height will not propagate in higher waveguide modes. The earth-ionosphere waveguide operates as a variable passband filter when propagating the lightning spectrum.



1.) At these frequencies the static bursts propagate with particular efficiency in the "waveguide" formed by the earth's surface and the ionosphere (See Figure 2). Tuning

through most of this frequency range, you will hear static that sounds pretty much like what you hear on your AM receiver. But if you tune below about 5 kHz you'll discover that sometimes (not always by any means), the crackle becomes a liquid musical "pinging", each pop of static producing a rapid descending note. These sounds are called tweeks. Typically, they drop a few hundred Hz in a fraction of a second, then cut off abruptly.

The mechanism of tweeks is quite well understood. When radio signals pass through a non-vacuum medium, those of higher frequencies usually travel faster than those of lower frequency. Since an impulse of lightning static starts out as high and low frequencies produced simultaneously, propagation in the earth-ionosphere waveguide necessarily sorts its frequency components; the highs arrive first, the lows later. The signal becomes dispersed over time; thus is referred to as dispersion. The degree of dispersion or "tweeking" is an indication of how far signals have traveled. Because of the nature of "waveguide" propagation, this is not necessarily an indication of point-to-point geographic distance.

Tweeks are generally heard at night (though they will often tend to appear late in the afternoon), and winter is probably their

best season. If you spend long enough listening to static and tweeka below 10 kHz you are almost certain to hear a few whistlers come howling through. These too are descending notes, but they occupy seconds rather than milliseconds, and they can be extremely loud, commanding the listener's attention in no uncertain terms!

Beginning with Barkhausen, early researchers toyed with the idea that whistlers, like tweeks, are dispersed lightning static. There was a great deal to recommend this explanation, but also one bad problem - nobody could find signal paths on earth that were anywhere near long enough to account for the huge amount of dispersion seen in whistlers. Propagation around and around the world was hypothesized, as were strange radio-reflective clouds somewhere out in space. But these theories didn't fit the observed phenomena very well. Since they seemed to resolve far fewer questions than they raised, nobody was very happy with them as explanations for whistlers.

Whistler research lapsed into a sort of limbo from the mid 1930s through WW-II. Whistlers remained: "Natural Phenomena, cause and mechanism unknown."

The war engendered unprecedented technological leaps. New techniques for recording and spectrum analysis emerged from the conflict to play central roles in the

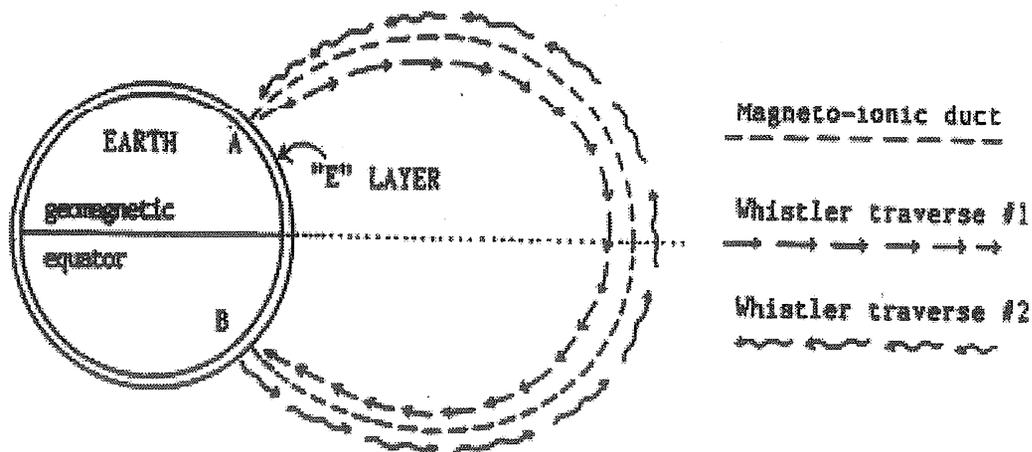


Figure 3. Whistler paths (after Helliwell). A lightning impulse near A propagates between earth and the E region of the ionosphere until it is trapped by a duct. The signal is then ducted to B in the conjugate region of the opposite hemisphere. A single hop whistler emerges into the earth-ionosphere waveguide at B. A reflected signal may be returned to A to be heard as a two hop whistler.

unraveling of whistler mysteries during the 1950s. L.R.O. Storey, R.M. Gallet, R.A. Helliwell, M.G. Moran and others were successful in applying new tools and careful observation techniques to whistler research. In the process, they developed a new view of earth's near-space environment and laid foundations for the field of magnetospheric physics.

As it turned out, the long dispersive whistler paths were found neither in terrestrial propagation nor in the depths of space - rather, they were traced to an intermediate region known as the magnetosphere. This is the region where earth's magnetic field interacts with the continuous (but varying) influx of charged particles known as the solar wind.

The solar wind consists of charged particles (electrons and ions) moving outward from the sun. Solar wind, magnetosphere and ionosphere are plasmas, hot, partially ionized gases. These charged particles in motion develop magnetic fields. Since magnetic fields are subject to interactive forces of attraction and repulsion, as the solar wind particles encounter earth's magnetic field both particles and the planetary field are perturbed. Energy is transferred, distorting the geomagnetic field into its now familiar teardrop shape, and solar wind particles are captured in spiraling courses aligned with the field. The plasma densities and the dimensions of the magnetospheric plasma environment happen to be suitable for the effective propagation of radio energy at whistler frequencies.

Broad spectrum VLF radio energy generated by lightning bursts under some circumstances escapes the earth-ionosphere waveguide to encounter field-aligned discontinuities (generally described as "ducts") in the magnetospheric plasma. The ducts extend between northern and southern hemispheres, arching to their maximum distance (several earth radii) from earth over the equatorial regions as shown in Figure 3. Field-aligned ducts within magnetospheric plasmas do in fact yield paths long enough to account for the dispersion of whistlers.

Simultaneous monitoring in northern and southern hemispheres has revealed that specific static impulses in one hemisphere do correlate with whistlers heard in the conjugate

region of the opposite hemisphere. Moreover, whistlers may rebound back and forth along a duct (or even multiple ducts) many times, generating progressions of echoes that become ever longer in duration, lower pitched.

Scientists were quick to realize that the study of whistler dispersion could yield valuable data about the characteristics of the magnetosphere. Every whistler is a magnetospheric probe!

BASIC GUIDE TO WHISTLERS. EMISSIONS AND ASSOCIATED PHENOMENA

STATIC - Static is the impulsive crackling and popping of lightning generated broad spectrum radio bursts. Static can be heard throughout the radio spectrum. Its character varies according to the structure of the lightning producing it, distance from the receiver and the paths over which it propagates. Static impulses are also referred to as sferics.

TWEEKS - Tweeks are sferics subjected to dispersive distortion by subionospheric propagation. They are sharp falling notes with a duration of 25 to 150 milliseconds.

WHISTLERS - Whistlers are descending tones generated through the propagation of sferics over very long paths formed by field aligned plasmas (ducts) in the magnetosphere. Whistler's magnetospheric propagation is between magnetic conjugate regions in northern and southern hemispheres. Terrestrial reception of whistlers results from subionospheric propagation of these signals.

Whistler duration ranges from a fraction of a second to several seconds. The frequency range of whistlers can extend from above 30 kHz to below 1 kHz but those readily heard with simple equipment will mostly lie between 1 and 9 kHz, with their maximum energy usually concentrated between 3 and 5 kHz. Whistlers are categorized according to hops. One hop equals a single traverse between conjugate regions. A one hop whistler is generated by lightning in the opposite hemisphere from the listener. It has traversed the magnetosphere

just once and as a consequence, it tends to be a high pitched whistler of short duration. Since the causative spheric is very far away, it is rarely heard in association with single hop whistlers.

Two hop whistlers are produced by lightning in the same magnetic hemisphere as the listener. The signal has traveled to the opposite hemisphere and echoed back to the region of its origin. Subject to roughly twice the dispersion of a single-hop whistler, its duration is much longer than its one-hop cousin. Causative spherics can often be heard in very distinct association with 2-hop whistlers. Delays of 1.5 to 3 seconds between spheric and whistler are typical.

Odd order hops (1, 3, 5, etc.) indicate opposite hemisphere lightning while even order progressions (2, 4, 6, etc.) follow from same hemisphere lightning. On occasion, whistlers generate multiple echoes or progressions known as echo trains. While trains exceeding about a dozen echoes are uncommon, progressions of more than 100 have been observed on rare occasions.

Whistler notes range from extreme] pure tones to breathy, diffuse swishes. The breathy quality is described as diffuseness. It results from whistler mode excitation of multiple ducts, with slightly different travel time for each duct serving to spread or diffuse the signal.

Whistlers were the first studied and most easily understood class of magnetospheric radio events but they are far from being the only ones that can be observed by a patient listener using basic tools.

VLF EMISSIONS - VLF emissions are naturally occurring phenomena found in the same frequency range as whistlers. In his book **WHISTLERS AND RELATED IONOSPHERIC PHENOMENA**, Robert Helliwell divides VLF emissions into 7 basic categories:

HISS - Hiss, as the term suggests, is a hissing sound. Unlike white noise, it is more or less band-limited. Its center frequency and bandwidth can vary widely with different conditions. Hiss may be stable in amplitude and frequency for minutes or hours. Or it may show distinct short-term fluctuations

which may or may not be periodic in nature. Hiss is often found in conjunction with other emissions.

DISCRETE EMISSIONS - Discrete emissions are brief, transient events. They may be pure or fuzzy tones which rise ('risers') or fall ('falters') in frequency. Sometimes falters abruptly turn about and rise in frequency as 'hooks'. Other descriptive terms that come to mind are 'chirps', 'croaks', "honks" and "barks".

PERIODIC EMISSIONS - When clusters of discrete emissions form regularly spaced repeating patterns they are known as periodic emissions. They may be singular or multiple, relatively frequency stable or drifting.

CHORUS - Multiple closely spaced or overlapping events are known as chorus. Chorus may resemble the sound of birds at sunrise but often it is reminiscent of croaking frogs or seals barking. Chorus is frequently found rising out of the upper edge of a band of hiss.

QUASI-PERIODIC EMISSIONS - These are events consisting of discrete emissions, periodic emissions or chorus which appear at long but fairly regular intervals - on the order of tens of seconds. They are less regular than periodic emissions.

TRIGGERED EMISSIONS - Sometimes one magnetospheric event triggers another. Triggered emissions are those which appear to be clearly associated with a triggering source. Whistlers, discrete emissions, manmade VLF signals and atmospheric nuclear explosions may all serve as triggers. Whistlers and other signals may also be seen to modify the spectrographic signatures of other events in the same duct.

THE ORIGINS OF VLF EMISSIONS

VLF emissions appear to arise from interactions above the equatorial region that involve incoming solar wind particles, the planetary magnetic field and plasma resident on the field lines. At whistler and emission frequencies the magnetosphere has the

potential to perform as an amplifier. (Gains of 20 to 50 dB have been observed.) This amplifier is subject to instabilities which are regulated by (among other things) the time constants of whistlers and other signals echoing back and forth along magnetospheric ducts. To take a simplistic view, the whole system can be considered as a gigantic electronic synthesizer programmed by solar and terrestrial processes. The resulting music can be complex, sustained and hauntingly beautiful.

ARTIFICIALLY STIMULATED EMISSIONS (ASES)

In the 1950s and 60s, powerful military VLF Morse Code transmissions were observed to stimulate emissions resembling elements of the rather mysterious "chorus" phenomenon. This led to the idea that it might be possible to perform active experiments in order to better understand the actual mechanisms involved in the production of whistlers and emissions, thereby refining our knowledge of the magnetosphere.

Research employing a powerful VLF transmitter at Siple Station, Antarctica, was carried out in the 1970s and 80s. Transmissions from Siple generated a variety of magnetospheric phenomena that were heard by a monitoring station in the magnetic conjugate region near Roberval, Quebec, and by a variety of satellite monitors operating within the magnetosphere. These experiments in the controlled excitation of events within the magnetosphere succeeded in greatly advancing scientists' understanding of the interactions taking place in the near space environment. They have also suggested many avenues for future research.

With the magnetosphere well established as the sensitive region within which the mechanisms governing whistlers and emissions operate, there has been considerable interest in discovering the effects of stimulation applied directly to that region. During 1989-90, the Soviet satellite ACTIVE attempted to accomplish this by passing large 10.5 kHz currents through a 20 meter loop antenna. Unfortunately, the loop apparently accidentally deployed in a very inefficient configuration. Several months of

monitoring by NASA, Soviet observers and private experimenters in the US found no effects, either on the ground or in space. These joint experiments were nonetheless successful in that they provided the occasion for participation by a number of amateurs and high school groups. Had ACTIVE performed as hoped, their data would have made a valuable contribution to the research.

School and amateur participation will continue in the spring of 1992, when the Space Shuttle based ATLAS 1 (ATmospheric Laboratory for Applications and Science) will deploy a VLF modulated electron beam instrument known as SEPAC (Space Experiments with Particle ACcelerators). The SEPAC electron beam will be modulated at frequencies between 50 Hz and 7 kHz as researchers attempt to analyze its propagation and interactions with magnetospheric plasmas. The high school and amateur ground station program, INSPIRE (Interactive NASA Space Physics Ionosphere Radio Experiments) will provide a large network of ground stations to determine the "footprint" and other characteristics of the SEPAC signal.

Not only has the past four decades of active and passive whistler research enormously enhanced our understanding of the vast interactions taking place in the magnetosphere, it has given us glimpses of similar processes on other worlds. Whistler-like signals have been heard in the vicinity of Jupiter, Saturn and Neptune. Even Venus and Mars make odd noises on VLF. It appears that planets having magnetic fields and turbulent atmospheres are likely to produce whistlers and related phenomena. The coming decades should signal the emergence of a new branch of science devoted to the analysis of planetary electromagnetic signatures at VLF and ELF. But as we speculate along these lines we should remember that we've only begun to understand the complexities of our own world's natural electromagnetic environment.

For the amateur observer, pursuit of whistlers represents a unique combination of challenges and rewards. Highly sophisticated receiving and recording equipment is not required - the basic tool kit needn't cost a fortune, and the parts of that kit which need to be constructed (or

commissioned) by the user are not particularly complicated. Even a rank beginner at electronic construction can build a workable whistler receiver. The greater challenge probably lies in seeking out radio quiet locations far from power lines and waiting patiently (or returning again and again) until something happens.

The rewards are inextricably bound up with the challenges. There is a genuine thrill to hearing these things for the first time (or the first hundred times!), particularly if one accomplishes the feat with tools built "from scratch". With increasing experience it becomes apparent that the variety of natural VLF radio phenomena is enormous. Many listening expeditions will be duds, but of those that produce results, no two are likely to be the same. If one makes recordings, the task quickly evolves from a quest to collect samples of the various phenomena to an ongoing process of gathering better samples. With over 60 hours of whistler tape on the shelf, I foresee no end to that particular process!

The scientifically inclined amateur will find numerous areas that invite research, including topics and phenomena that have been touched upon only lightly, if at all, by professional researchers. For instance, the possibilities of a large network of coordinated monitors have never been explored simply because there has never been a large number of monitors.

There is a great deal to be done in the area of electronic design and signal processing. Prototype 'comb filters' have been developed to remove power frequency harmonics from receivers, but there is clearly more to be done in this area if the whistler hunter is to be freed from the necessity of going far from the power lines to do his thing. An alternative approach to the power line interference problem lies in the development of remote receiving and recording systems that can be automated or remotely controlled. Impressive hardware and software for spectrum analysis exist in the professional world, and the well-to-do amateur can certainly acquire a rudimentary signal analysis capability "off the-shelf". However, the field is wide open for development and innovation.

RECEPTION BASICS

Whistlers and other VLF phenomena that can be detected by simple receivers occur at frequencies ranging from a few hundred Hz to above 10 kHz. These frequencies are readily accessible to human hearing but even so, whistlers and emissions are not directly audible. This is because they are electromagnetic events which do not produce the mechanical vibrations in the air that our ears detect as sound. In order to hear whistlers we must convert their electromagnetic activity to acoustical vibration. Conversion is accomplished with a transducer - a loudspeaker or headphone that uses electrical energy to move a sheet or cone of material that in turn pushes and pulls air molecules to produce sound.

In theory, all that is needed is to connect a transducer, such as set of headphones, between an antenna and the ground. But in practice, unless the antenna is miles long, the amount of energy that can be intercepted from whistlers is too small to make much in the way of sound. The problem is resolved by placing an amplifier between the antenna and the transducer. While this is quite straightforward, manmade interference immediately above and below the frequencies of interest dictates careful control of amplifier characteristics if satisfactory reception and recording is to be achieved.

INTERFERENCE FROM THE LOW SIDE - Modern civilization runs on AC (Alternating Current) electrical power. Practically all inhabited areas are heavily threaded with wires of the electrical power grid. These power lines deliver electricity at frequencies of 50 and 60 Hz, the frequency depending upon the part of the world in which you reside. This system presents the whistler hunter with a serious problem: the flow of alternating current in power lines induces alternating electric and magnetic fields in the vicinity of the lines. These fields are readily intercepted by the sensitive antennas and amplifiers used for whistler reception. They are heard as a humming sound, overwhelmingly strong in the vicinity of power lines, progressively weaker as

distance from the source is increased. The hum consists of a combination of the fundamental 50 or 60 Hz note with numerous harmonics at multiples of the fundamental frequency. Hum harmonics may extend up to several kHz but the lower frequencies are generally strongest.

To reduce the effects of hum it is helpful to incorporate a high-pass filter in the receiver to attenuate frequencies below about 1 kHz. Since the worst hum often lies below 1 kHz and most whistler activity is above that frequency, this is a quite workable compromise. Where power line interference

spectrum, the better solution is to find a more nearly interference free site. Highpass filtering is not a cure-all. Operation too close to power lines will still result in hum dominating the receiver. Given quiet conditions and a large antenna, power line harmonics extending to several kHz will be heard from almost anywhere you can go. But once you are one or several kilometers from their source they will be weaker than most natural radio activity. Even a few hundred meters may be sufficient to hear activity.

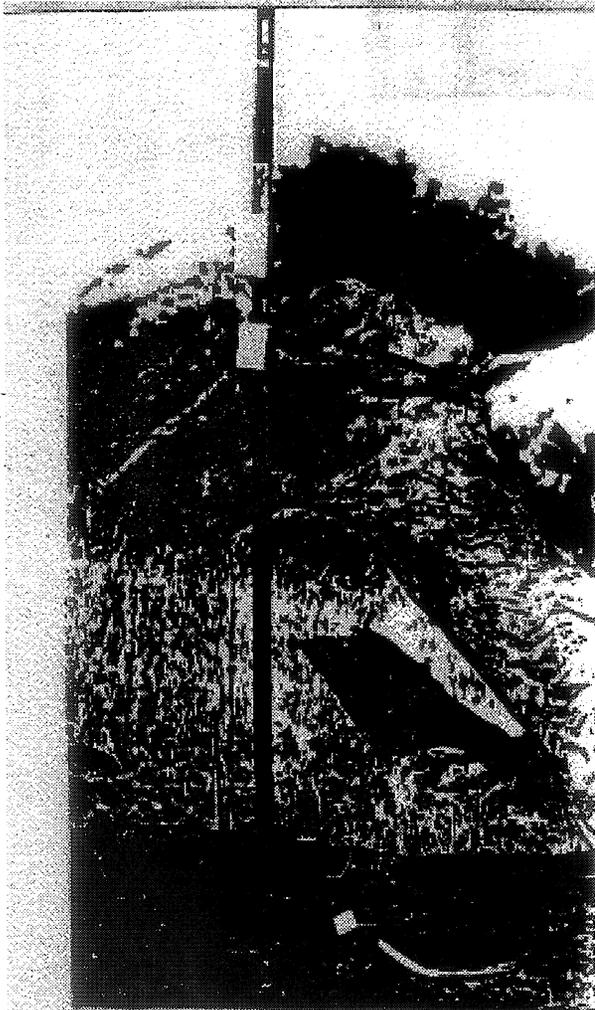


Figure 4a. Temporary field setup of an E-field whistler receiver, with monitor amplifier and whip antenna mounted on a piece of 1x2 lumber. The ground system, consisting of two rods fabricated from 1/2" conduit, is visible on the left.

is very severe, it may be necessary to raise the high pass frequency as high as 5 kHz. Since this sacrifices much interesting whistler

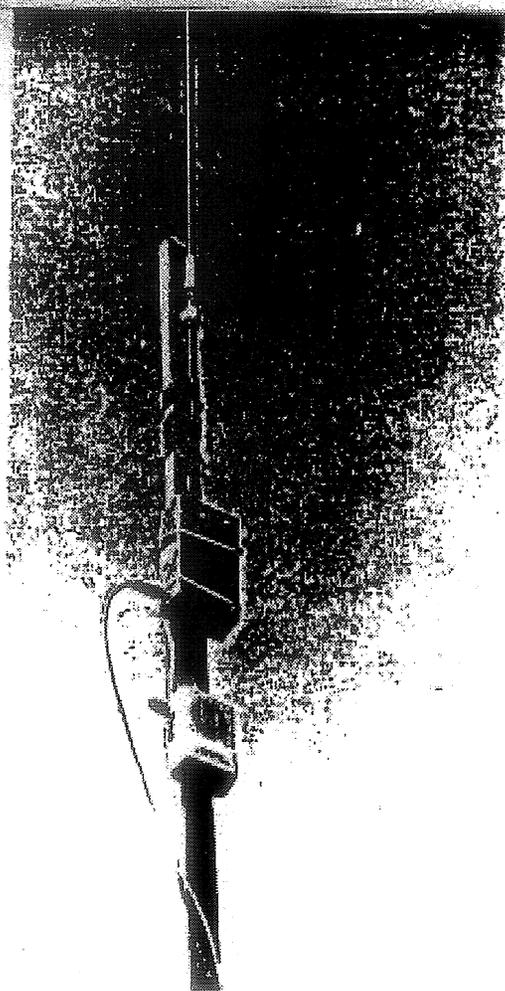


Figure 4b. Detail of whip antenna, E-field receiver and monitor amplifier mounted on 1x2 lumber.

INTERFERENCE FROM THE HIGH SIDE - Radio navigation and communications services utilize very powerful transmissions

just above the frequencies where whistlers and emissions are most easily heard. The OMEGA navigation system's 10.2 kHz channel is the lowest of these interfering frequencies. If your ears have reasonably good high frequency response, you can hear OMEGA on 10.2 kHz and several higher frequencies. It sounds like a progression of high pitched dashes about 1 second long. Because the 8 stations of the OMEGA network are scattered all around the world, some of the dashes are much stronger than others.

If you find that you are hearing and recording pure OMEGA tones at 10.2 kHz and above, all is well. But if you hear or record them at a lower frequency, or if they have a warbling burbling character, overloading is taking place. Overload can happen quite easily because the manmade signals tend to be much stronger than the natural phenomena we are seeking. Cassette recorders are particularly prone to high frequency overload problems.

To minimize difficulties with high frequency overload it is useful to attenuate frequencies above about 9 kHz. This is accomplished with lowpass filters and by selection of component values that reduce high frequency response.

ANTENNA AND GROUND REQUIREMENTS - The following discussion pertains mainly to the use of whip and wire antennas which operate in conjunction with earth ground or a counterpoise to intercept the electric field component of radio signals. However, no discussion of VLF antennas would be complete without some mention of loop antennas. Loops have three great virtues. They are directional, allowing interference to be nulled and bearings to be taken on signal sources. Since they utilize the magnetic component of radio signals they are largely immune to desensitization by surrounding vegetation. Loops can be calibrated relatively easily, simplifying the business of making quantitative measurements under field conditions. On the minus side, effective loop receiver designs are more demanding and expensive than E-field receivers of comparable sensitivity. Loop antennas are a challenge to build and, when they are

physically large enough to be highly sensitive at whistler frequencies they are also a real problem to transport. My recommendation to the beginner is to start out with E-field systems until you have defined a personal need for a loop.

E-field antennas (whips, wires and conductive objects insulated from ground) are heavily influenced by their relationship to ground, surrounding terrain and vegetation. In addition, every installation is subject to a critical threshold beyond which increasing antenna size or height will only result in overload of the receiver or recorder by signals outside the frequency range of interest. It is good to keep in mind that this threshold is subject to variations in propagation -

often a set-up that is perfectly clean by daylight will exhibit problems occasioned by propagation changes that begin around sunset.. For these reasons, only general guidelines can be given with regard to E-field antennas- the "fine tuning" must come from each user's experience.

The antenna should be small enough to avoid overloading under normal conditions and it should be large enough to provide an input that is usually strong in comparison to circuit and tape noise. Ordinarily this input level will be defined by substantial power line hum or a more or less continual crackle of static.

If you are operating in a clear area, as in the middle of a few acres of open field, on a hilltop or a ridge, your receiver will probably be happy with 6 foot whip such as Radio Shack's #270-1408. For the sake of sensitivity, it is important to keep the base of short whips at least a few feet above the ground. I've found the "walking stick" configuration illustrated in Figure 4 provides a very convenient way to carry and use sensitive E-Field receivers.

If you find yourself in woods or a close canyon the 6 ft whip will be virtually useless due to local attenuation of the electric field component. The solution is, to capture more signal by substituting a longer antenna made of wire. Somewhere between 30 and 200 feet should do the trick. Just about any sort of wire will work, as long as it is strong enough to avoid breakage. Wirewrap wire or plastic covered hookup wire is fine for

temporary or portable installations. It is important to get the wire off the ground - the higher the better and probably the more nearly vertical the better, but there is no need to go to extremes. Unless the wire is strung along the top of an existing fence, always make the antenna high enough to clear people, horses, cattle and large wildlife. For a temporary installation it is fine to drape the wire over limbs and brush. However, the antenna will pick up noise from leaves and twigs blowing against it (or sometimes even moving nearby), so it is best to suspend the wire from just a few points and protect it from all unnecessary contact. This is true regardless of whether or not the antenna wire is insulated.

It should be noted that these antennas, minuscule in terms of the wavelengths were dealing with, function essentially as capacitors. Whips and wires are convenient to use, but any conductor that can be elevated above and well insulated from the ground will also work. I've found a 6" diameter copper sphere works about as well as a 4 foot whip mounted at the same height. My pickup truck, parked on a dry open ridge and used against a ground stake makes a more sensitive antenna than a 5 foot whip mounted several feet above the track bed.

GROUND - The ground connection does not have to be elaborate - you have a good enough ground when the receiver operates in a stable fashion. When the ground is missing or inadequate, the receiver will break into howling oscillation as the output level is advanced.

Buried pipes and metal fence posts sometimes provide convenient grounds. It's a good idea to carry a variety of clips and clamps for tying on to them. Don't neglect some sandpaper to clean up the contact points and extra wire to reach them. Serviceable ground stakes can be made from 1/2" electrical conduit or copper tubing. Cut the tubing in lengths of 14' to 24'. Use a hammer to mash one end flat for 3 or 4 inches, then use a hacksaw to cut a point at the end of the flattened section. Use a stainless steel hose clamp to attach your ground wire near the other end of the stake. In the field, one to four stakes of this type, hammered into the ground 10" to 12" will

usually provide an adequate ground connection. For temporary and portable installations it is important not to drive the stakes to the point where they cannot be extracted. Permanent installations can incorporate one or more commercial ground rods, driven fully into the ground. If short stakes are used where the ground is sandy or very dry, it may be helpful to saturate the area around the the ground stakes with a few liters of saltwater.

COUNTERPOISE GROUNDS - Sometimes a direct earth ground is impractical. You may be situated on hard rock or ice. And of course if the receiver is mobile, ground rods are out of the question. The solution is to use a counterpoise to establish capacitive coupling to the ground. The counterpoise can consist of one or more wires with a total length several times that of the antenna. Counterpoise wires may be laid directly on the ground or suspended above it. Mobile communications systems use the vehicle body for a counterpoise, and you can do the same thing if you are operating from a car or truck. (Electrical noise will make the whistler receiver useless while the engine is running.) In general, the self capacitance of the counterpoise should be much greater than that of the antenna. When the whistler receiver is equipped with a short whip, the operator's body will often provide an adequate counterpoise. A finger ring improvised from copper wire or thin brass or galvanized strap and connected by a length of flexible wire to the ground terminal makes a convenient way to connect yourself to the receiver. If the earth ground connection is marginal, this type of body contact will usually clear problems.

FIELD TESTING THE RECEIVER - Once you have a receiver that proves itself by producing loud hums and buzzes when operated in your home or lab, it is time to do some field tests. Field-tests are important to make sure everything really is working properly, and to familiarize yourself with the equipment and procedures you'll be using later. It is also a good way to look for quiet monitoring sites.

The first criterion for a site is that it be some distance from any AC power line. Just how great this distance should be is a matter

of debate, but 300 to 400 meters ought to be adequate for field testing.

For a full-scale field check, your kit should include receiver, antenna, ground stakes, monitor amp, headphones, recorder, spare batteries for everything. Take a full set of connecting cables and a couple of spares with whatever adapters are needed to replace lost or damaged cables. You will need microphone, recording tape and a notebook to keep track of your tests. Bring some spare wire and a few clip leads. Two or three "C" clamps may come in very handy, as will a basic tool kit consisting of hammer, wire cutters, a couple of screw drivers and a small adjustable wrench. (Yes, this seems like a lot of stuff, and later you may well decide to dispense with a quite a bit of it - but you can't try the things you didn't bring, so start out by erring on the side of excess.)

Having found a promising looking site, put up an antenna (try a whip if you are in the open, a wire if in the woods) and ground or counterpoise. Turn on the receiver and monitor. You should hear the click and crackle of sferics, their loudness and frequency depending upon the time of day and state of the weather within a few thousand miles. Unless the sferics are very strong and dense, you will probably hear the background hum of power lines as well. Depending upon the background level and the frequency response of your hearing, you may also hear the shrill tones of Omega as a series of dashes about 1 second long. With luck, you'll even hear whistlers or chorus, but don't count on it.

Make a test recording beginning with a microphone announcement describing the setup. Then try recording various receiver settings, cutting back to the microphone to provide running commentary on what you are doing. Ideally you should work with a recorder having an independent playback head, switching between tape input and output to arrive at settings where they sound identical. If this feature is not available, rewind and check the test tape immediately after recording. If the recording is distorted or noisy, or if things appear on the tape that are not heard on the direct monitor - try other settings, lengthen or shorten the antenna. Even if you don't fix the problem right away, these adjustments may give important clues

as to its source. Take notes - things that seem obvious at the time tend to fade or become distorted in memory.

When you get home, review your tape and notes. Think about what could be improved on the next expedition.

WHISTLER HUNTING

Once the receiving system is working properly and you've gotten accustomed to setting it up, the time has come for more serious whistler hunting. The questions are 'When?' and 'Where?'

WHEN? Whistlers and emissions may be heard at any hour of the day or night but odds are best around dawn. Atmospheric and manmade noise are usually at their lowest then and the magnetosphere seems to be especially sensitive as well. If you begin listening by the first glimmer of daylight and continue until the sun is above the horizon, chances are fairly good that you'll catch the day's best activity. But this is only a general rule. Sometimes nothing will happen at dawn and there will be a peak of activity at sunset or a few hours after dark.

Whistler and emission activity seems to occur in runs of about 3 to 7 days. There are also periods of days and even weeks with very little activity. At one extreme: more than 20 whistlers a minute. At the other: less than one per hour or none at all.

VLF emissions often appear during or shortly after magnetic storms. Magnetic storms are produced by interactions between earth's magnetic field and particles ejected from regions on the sun undergoing violent activity. Sometimes the activity persists through the sun's 27 day rotation period. This can lead to terrestrial magnetic storms and VLF emission events that follow the periodicity of roughly 27 days. Whistler activity also tends to be especially interesting during and after magnetic storms. Long spectacular echo trains are most common at such times.

WHERE? Locally speaking, the place to go is as far as you find it practical to get from AC power lines. Bear in mind that diminishing returns are involved here. If you're a kilometer from power lines you'll

have a moderate hum level unless atmospheric noise (lightning static) is very strong. Doubling the distance to 2 kilometers will make a quite noticeable improvement as will doubling the distance to 4 kilometers. When you reach the point where you are unable or unwilling to go twice as far as you've already come it's time to unpack the equipment and do some listening!

Surprisingly good sites can often be found along public roads. Look for new roads and scenic routes that have been built away from power lines. Seek out rough terrain and complex shores that tend to separate roads from power lines. Elevated scenic outlooks sometimes diverge from the power lines. Even 1/2 km can make a big difference.

If you're into mountain climbing or backpacking, the place to listen is wherever you feel line stopping. Overnight camps are probably best because they get you set for the dawn window. If you have access to a boat and even a medium size body of water, by all means give it a try. Use a whip antenna with its base at least a couple of meters above the water (or the boat's structure if it is metal) and ground the receiver with about 30 meters of wire in the water. Excepting running lights and any other apparatus required by law to be kept on, turn off all electrical systems while monitoring.

In general, whistler reception is best at middle geomagnetic latitudes and worst in the equatorial regions. Whistlers and emissions can certainly be heard in fair number anywhere in the US. There do appear to be differences in the character and occurrences of whistlers heard in Eastern and Western North America. Amateur observations could readily address questions of how reception differs between the two coasts and how either coast may differ from mid-continent. While low latitude (below 20 degrees geomagnetic) reception of VLF phenomena is a good deal more challenging than reception at middle and high latitudes, this also represents an area where relatively little research has been carried out. Patient investigation of the tropical VLF environment might yield some interesting surprises.

If you're fortunate enough to live some distance from the power grid, you

could be in the enviable position of having first-rate listening with all the comforts of home. The receiving system outlined here is adequate to get you started but later you may want to go to a large loop system that can null either the distant power lines or your household's electrical noise. (With careful selection of the loop's location, you can do both.)

RECORDING

You don't have to record the VLF phenomena you hear, but if you don't, who's going to believe your wild tales of strange sounds overheard while everyone with an sense was sound asleep? Very little research can be accomplished in the absence recordings.

Unless quality portable reel-to-reel or digital tape equipment is available, the best way to get into whistler recording is with standard audio cassettes. Any cassette recorder having an external microphone input should work. Inexpensive machines tend to generate more noise and distortion than expensive recorders. Machines whose recording level is controlled automatically (practically all inexpensive recorders) tend to exhibit audible gain "pumping" in response to sferics. If the sferic density approaches the ALC (Automatic Level Control) time constant, the recorder will be effectively desensitized by transient peaks. So it is best, though by no means essential, to use a recorder that has manual level control and/or an input attenuator. In general it is best to leave peak limiters off for VLF recording - saturation by transient peaks costs less data than the post-peak desensitization imposed by a limiter. However, in monitoring "live" reception, a limiter at the monitor input or output can be a real ear-saver.

I've had quite satisfactory results with Marantz PMD 430 recorders. At around \$450, they represent about the last step before spending a lot more on "professional" equipment. A key feature on this machine is the third head, which allows real-time monitoring of what is actually going on tape - instant comparison between input and output for optimum adjustment of receiver and recorder. Monaural Marantz machines cost less and work fine, though you sacrifice the

convenience of 2 channel operation by going mono. If you can possibly afford a 3-head machine, you'll find it well worth the price. On the other end of the scale, I've gotten usable tape on a recorder that cost under \$30 at a Radio Shack sale.

Improved dynamic range and frequency coverage can be had with professional 1/4" tape equipment. Nagra is probably the best choice - but even used machines cost thousands of dollars. If your recorder is to be used exclusively for whistler work, it should be modified to provide flat frequency response. This will reduce problems with Omega and MSK overload, permitting extended high frequency coverage.

The Sony "Walkman" digital audio recorder is now around \$650. I have no direct experience with this technology but in theory its extended frequency coverage and dynamic range should bypass many of the problems associated with analog recording of VLF phenomena.

RECORDING HINTS - Take spare batteries. Reserve used and questionable batteries for flashlights. Since you are going to a lot of trouble and some expense to record VLF phenomena, invest in good tape. This doesn't necessarily mean the most expensive tape you can find, but avoid the el-cheapos that are subject to mechanical failure and oxide shedding. I use TDK SA (Type II, chrome) tapes. They seem to be a little less vulnerable to high frequency distortion than quality "Type I" low bias tape. If your recorder is designed operate only with "Type I" tape, use it. "Metal" tape appears to provide no significant advantage over "Chrome". Unless there is an urgent need to produce very long continuous takes, don't use cassettes longer than 90 minutes. If you do wind up with longer cassettes, dub them immediately to 60 or 90 minute tapes, using the gentlest playback machine you can find.

If your recorder offers a tape noise-reduction system, don't automatically turn it on for VLF work. In my experience (limited to Dolby B and DBX) the noise reduction simply introduces distortion. VLF is rarely quiet enough for the noise level of good tape to be a factor but Omega pulses modulating a

noise-reduction may ruin otherwise good recordings.

Label cassettes and cassette boxes. Keep a log that includes the date and time of each take, along with remarks as to contents of the recording. It is extremely helpful to make a voice announcement at the beginning of each take, giving tape number, tape side and the sequential number of the take on that side. Example: Tape 26, Side A, Take 4. Or more simply, just- 26 A 4. You may think at the time you'll surely remember what you're doing, but will this really be the case a few sessions later? I experience great frustration when people send me field recordings that lack voice announcements between takes, forcing me to take great care to find the transitions from one take to the next and to keep count of all the takes so that I can be fairly sure that what I'm hearing corresponds to the notes I'm reading!

If you plan to dub and edit your field recordings you should aim for capturing the widest frequency range the system allows. You can take your time getting the sound you want through equalization during dubbing - the more you get on the original tape the more you have to work later. If the field recording is to be the end product, it makes sense to manipulate frequency response to emphasize the subject. If the recording is destined for spectrum analysis, don't mess with it - just go for as broad and flat as possible.

It is a good idea to log dates and times in UTC (Universal Time, Coordinated) rather than local time. This practice avoids ambiguities that can be terribly frustrating to anyone subsequently working with the recordings. It also means that your data can be easily examined in the context of other geophysical records kept in UTC. Where whistler recording is concerned, for all practical purposes UTC is the same thing as GMT (Greenwich Mean Time).

If you have a portable short-wave radio, it is always possible to find out the UTC time by tuning to stations WWV and WWVH on 2.5, 5, 10, 15 or 20 MHz. Time is announced on the minute and one or more frequencies are usually readable.

If you use a stereo recorder, you can run WWV on one track to provide an accurate time reference. Alternatively, if you are getting at least one 10.2 kHz OMEGA on

tape, all you need is a WWV announcement on the head of a take. OMEGA dashes provide super-accurate markers as long as the tape is rolling. If you decide to use a two channel system, run tests to make sure there is no audible "bleedthru" from one track to the other. Also check for head misalignment by recording completely different material on the left and right channels of your field recorder. Then playback on a couple of good home machines to make sure their heads are tracking with your recorder. If the field recorder fails this test have it adjusted or refrain from two channel recording - use only one track or put the same information on both tracks.

When I find something especially unusual or interesting happening on VLF, I try to get the WWV announcement at 5 minutes past the hour and run tape of the VLF event for at least a minute thereafter. This particular time is chosen because at 5 past each hour, recorders on ELF/VLF receivers in Greenland, New Hampshire, Italy, California, Japan, New Zealand and Antarctica automatically roll to capture a minute of whatever is happening from 10 Hz through 32 kHz. This is part of an ongoing

past the hour - just get WWV at 5 past and run tape until you have a representative sample. This procedure improves the chances of getting simultaneous recordings. Simultaneous data are far more useful than scattered hunks of random data.

SPECTRUM ANALYSIS - It is possible to tell a great deal about natural radio phenomena just by listening to them. A practiced listener will notice and describe things that utterly amaze the beginner. Much valuable data has been generated by trained listeners painstakingly logging the contents of recordings. But when it comes to measuring complex variations of signals immersed in a noisy interactive environment, the ear is a limited instrument. The whistlers won't sit still, there is nothing to hold on to! What is needed is some way to reduce these fleeting events to graphic representations that will sit still to be measured.

In the early 1950s, Owen Storey (then a graduate student at Cambridge University) felt this frustration so keenly that he built a primitive spectrum analyzer which was capable of creating frequency vs. time plots on a strip chart recorder. In present day

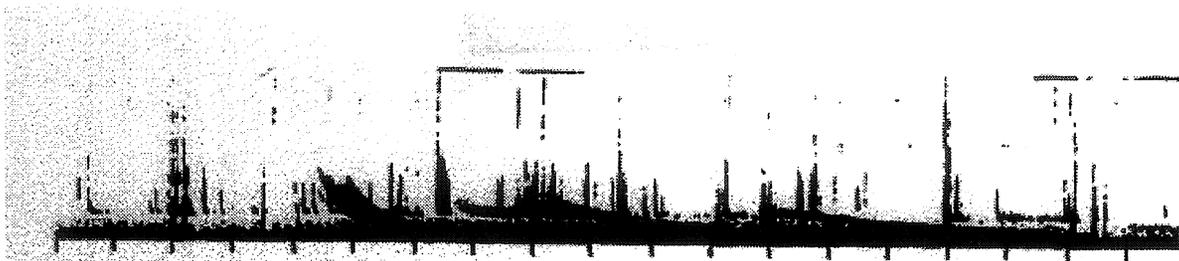


Figure 5. Spectrum analyzer view of two whistlers and a multiband whistler with echoes. Recorded by the author at San Blas, CA on April 2, 1960. The waveguide cutoff frequency is apparent in the abrupt, uniform termination of the pulses at about 1.6 kHz. 10.2 kHz OMEGA dashes appear at the top of the strip. The vertical scale is from 0 to 10 kHz and the horizontal scale is marked in seconds. Courtesy of STARDab, Stanford University.

survey of radio noise conducted by Stanford University. I got into the 5 minutes past the hour routine while making site sensitivity comparisons with the CA receiver.

The Noise Survey receivers are not particularly sensitive or free of manmade noise, and they are very widely separated. Where weak VLF phenomena are concerned, they are probably of little use. But the network does establish a minute in each hour that is known to be monitored, and I urge amateur observers to take advantage of that minute. Don't necessarily stop recording at 6

terms this was an extremely low resolution instrument, but it was good enough for Storey to define the essential characteristics of whistlers. In so doing, he also defined the course of much of the research that has followed. Storey's tools were quickly made obsolete by a new generation of instruments designed for the analysis of speech characteristics. These devices, like Storey's depended upon passing the signal through a comb of narrow filters - but instead of actuating pen and ink, the new machines left their mark on a moving strip of 35 mm

photographic film or paper, each filter controlling a light source focused on a narrow section of the passing film. Figure 5 shows an example of such a spectrogram. In recent years VLF spectrum analysis has been revolutionized by digital technology. Now anyone with a sufficiently powerful personal computer can produce quite satisfactory frequency VS time

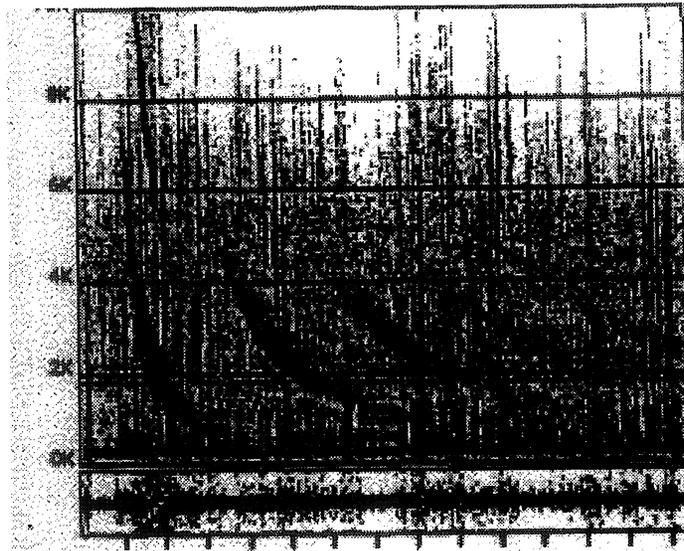


Figure 6. MacRecorder (tm) "sonogram" of whistlers recorded by the author at San Simeon, CA on March 14, 1989. Vertical scale is from 0 to 11 kHz and horizontal scale is marked in seconds. The narrow display at the bottom shows the amplitude of the wave as a function of time. In the "sonogram" black corresponds to maximum signal intensity.

plots (MacRecorder(tm) calls them "sonograms") from whistler recordings. Figure 6 shows a "sonogram" produced on a Macintosh II with MacRecorder(tm). MacRecorder(tm) is a product of Farallon Computing, Inc. It uses an 8 bit analog to digital converter in conjunction with software to perform a variety of audio frequency analysis functions: waveform displays, frequency vs. amplitude plots and frequency vs. time plots. Several sound manipulation and editing functions are also included but these have little application to whistler work. Lack of an on-screen time scale and an expandable frequency scale is frustrating, but at less than 1/10th the cost of competing products, MacRecorder(tm) is worth a little hand labor. List price is around \$250, with substantial discounts available. A new version is due in 1992. While many MacRecorder(tm) functions will work on a Mac Plus or Classic, the MacII is the smallest machine that will support sonograms. The smaller computers can produce what Farallon calls "spectrograms". These are frequency VS amplitude plots, with time incorporated as the "Z axis". They are not particularly useful for the interpretation of whistler type data.

Different organizations and authors use the words "spectrogram", "sonogram" and "sonograph" with various and sometimes conflicting meanings. When you encounter

these terms it is a good idea to double-check on their utilization.

THINGS THAT CAN GO WRONG

Troubleshooting lists are always frustrating, and I'm sure this one is no exception. But it does cover many of the more likely problems. It MIGHT help solve something in a hurry!

Start by asking yourself

some basic questions: Has each element in system worked in the past? (Don't forget cables and clipleads.) Do monitor, recorder and receiver work on their own? Have these devices previously worked properly when connected together? Try to localize the problem but remind yourself that your assumptions may lead you upstream or downstream of the real difficulty.

NO OUTPUT REGISTERS ON MONITOR OR RECORDER.-

- 1-Power off.
- 2-Battery dead or disconnected.
- 3-Connector not connected or connected to the wrong thing.
- 4-Damaged cable or connector.
- 5-Mechanical failure: open connection or short circuit.
- 6- Failure of electronic component.

FEEDBACK (HOWLS, SQUEAKS, SQUEALS):

- 1-Monitor, recorder, speaker, headphones or associated leads too close to antenna.
- 2-Ground missing or inadequate.
- 3-Bad connection to or in antenna.
- 4-Gain at monitor or recorder too high.

DISTORTION IN MONITOR OR RECORDER:

- 1-Excessive input level to recorder or monitor.
- 2-Excessive input to receiver.
- 3-Low battery.
- 4-Overloading from out-of-band signals.
- 5-Partial failure of connection or component.

HUM, BUZZ:

- 1-Too close to power lines, a generator or running vehicle.
- 2-Pickup from recorder motor.
- 3-Antenna too close to clock, motor or digital device.

VOICES, MUSIC:

- 1-Overload from Am or SW Broadcast signals.
- 2-Detection by rectification in antenna or ground system.
- 3-Pickup of audio frequency from nearby radios, entertainment systems or telephones.

TONES(ABOUT 1 SEC. LONG AT FREQUENCIES BELDW 10 KHZ)

- 1- Overload from OMEGA.

BURBLING SOUNDS:

- 1-Overload by MSK (Minimum Shift Keying) from military VLF -stations.

TICKING (10 HZ RATE):

- 1-Overload or detection in antenna or ground from 100 kHz Loran-C radionavigation.

RECORDING DISTORTED, MONITOR CLEAN:

- 1-Overload of recorder @ out-of-band signals.
- 2-Recorder batteries failing.
- 3-Incorrect tape bias.

SCRATCHING SOUNDS, WIND NOISE, INSECT NOISES:

- 1-Antenna rubbing its supports, moving in wind or somehow picking up signal from flying insects. The shorter the antenna the

more of this sort of interference you'll experience. Its not a defect so much as a fact of life.

CURING DISTORTION AND OVERLOADING: First, try reduced setting of receiver output level, monitor gain and (if available) recorder level. If this fails to cure the problem, check or change batteries. If the batteries are OK, the distortion probably results from excessive input to the receiver.

To reduce receiver input you can shorten the antenna. If pruning the antenna is impractical, you can insert a variable resistor (500 K to 1 M) between antenna and receiver. Set the resistor just beyond the point where distortion disappears.

If you are working with a loop antenna, try rotating the loop to a position that reduces or eliminates the distortion. This may make AC hum worse, in which case it becomes necessary to choose the lesser evil. If the loop is a very one without a rigid frame, can also try reducing the loop's size - for instance, make it lower and narrower. If the loop is of the rigid portable type, in the unlikely event that rotating it fails to null the overload source you can try tilting it out of the perpendicular to reduce overall sensitivity.

Persistent overload from local sources may require the installation of filters or traps designed to eliminate the offending signal. Such measures should be applied as close as n practical to the receiver's input stage.

Overload conditions can change with propagation. Overloading is more likely during night than day and most likely of all around dawn, so it is good to have a "trimming" option handy.

PRECAUTIONS

Whistler hunting is a fairly safe activity, but there are a few precautions that should be observed. The dynamic range presented by natural radio sounds is enormous. Using headphones to listen to static crashes at high volume levels can cause permanent hearing impairment. So beware of turning up the level to hear more - it doesn't really help. Instead, what happens is that the ear-brain system is desensitized, leading you to turn up the volume some more in a vicious

cycle that can take you over the threshold of ear damage. Instead of turning up the volume, take breaks from listening and turn the volume down a bit when you put on the headphones again.

Lightning in the vicinity of your monitoring site poses a hazard to you and your equipment. If lightning is visible or thunder audible it is a good idea to disconnect your equipment, ground the antenna and seek shelter. Don't under any circumstances do antenna work during thunderstorms!

Stay off of private property unless you have obtained permission to use it. Always clean up after yourself, removing antennas and ground stakes when monitoring is completed.

GLOSSARY

Not all of the following radio and radio-geophysical terms appear in the preceding text. However, you are likely to encounter them in other references, so they've been included for your convenience. Terms used as subject headings in the "Basic Guide to Whistlers, Emissions and Associated Phenomena" have not been repeated here.

ALPHA - A Soviet radionavigation system occupying 3 channels between 11.905 and 14.881 kHz, heard as a series of dashes about 0.3 seconds long.

B-FIELD - The magnetic induction field component of electromagnetic waves.

CONJUGATE POINT - In whistler work this refers to magnetic conjugates which are the points where a magnetic field line intersects the surface (or some defined level above the surface) in opposite hemispheres.

COUNTERPOISE - A large conductor substituted for or supplementing an earth ground connection.

CW - Common term for Morse Code.

DISCONTINUITY - A region where an abrupt change in a quantity occurs. In the case of whistlers, abrupt changes in electron density within the magnetosphere and aligned

with geomagnetic field lines result in waveguide-like propagation of VLF radio energy.

DISPERSION --The separation of higher from lower frequencies that produces whistlers. When electromagnetic waves propagate through absorptive media such as the magnetosphere and the ionosphere, the highest frequencies travel fastest, the lowest most slowly. The longer and more absorptive the path the greater the dispersion.

DIFFUSENESS - The degree to which whistlers depart from a pure tonal quality to become breathy or "swooshy". Diffuseness is a result of multi-path propagation slightly offsetting signal components in time.

DUCT - In magnetospheric propagation ducts are assumed to be field aligned discontinuities in the plasma whose characteristics produce waveguide-like behavior at VLF frequencies.

E-FIELD - The electric field component of an electromagnetic signal.

ECHOES - Whistlers reverberating back and forth through the magnetosphere, becoming progressively dispersed and shifting to ever lower frequencies in the process. Progressions of several echoes are known as **ECHO TRAINS**. Echoes may be more precisely defined in terms of HOPS.

ELF - Abbreviation for Extremely Low Frequency. Formally defined as 300 to 3000 Hz but also frequently used as a generalization or to describe a different range of frequencies.

GEOMAGNETIC LATITUDE - Approximately, latitude in the geomagnetic coordinate system as defined by the geomagnetic poles. Tilted about 11 degrees with respect to geographic coordinates.

GEOMAGNETIC POLES - The poles of the best fit centered dipole model to the earth's magnetic field. Not identical to the magnetic poles.

GROUND-GROUNDING - Connection of a circuit to a large conductor the largest being the earth.

HERTZ - The frequency of a wave in cycles per second. Abbreviated Hz. One kilohertz (kHz) equals one thousand cycles per second, one Megahertz (MHz) is one million cycles per second.

HOPS - In relation to whistler mode propagation one hop is considered to be a single traverse of the magnetosphere. A one-hop whistler originates in the opposite hemisphere and has traversed the magnetosphere only once. A two hop whistler makes two magnetospheric passes, returning to its hemisphere of origin. In subionospheric propagation, hops are regarded as the ionospheric reflections between transmission and reception points on the surface.

IONS - Atoms or molecules that have acquired either a negative or positive charge.

IONOSPHERE - The region extending above about 60 km to beyond 100 km altitude, where the concentration of ions is large enough to influence radio propagation. It is divided into several regions: D (60 to 100 km), E (100 to 150 km), F (150 to 1000 km). The F region is further divided into F1 and F2 regions, with F2 blending into the magnetosphere.

MAGNETIC STORM - Disturbance of the geomagnetic field, usually the result of interactions between charged particles from solar disturbances and the geomagnetic field.

MAGNETOSPHERE - Broadly defined this is the region of space within which the motion of charged particles is controlled by the geomagnetic field. However, this definition includes most of the ionosphere and common usage places the magnetosphere's lower boundary around the F2 ionospheric region.

MAGNETOPAUSE - The magnetosphere's outer boundary, extending to a geocentric distance of about 10 earth radii on the

daylight side and beyond the moon's orbit on the night side.

MSK - Minimum Shift Keying. The modulation mode commonly employed by high power military VLF transmitters. Produces a burbling sound in conventional receivers or when overloading a whistler receiver.

OMEGA - A global radionavigation system occupying channels between 10.2 and 13.6 kHz. Heard as a series of 0.8 second dashes.

PLASMA - An ionized gaseous medium.

PLASMASPHERE - An approximately toroidal volume of space surrounding the earth where the density of the plasma is above about 100 particles per cubic centimeter, with its outer boundary (the plasmopause) aligned with geomagnetic field lines whose average equatorial crossing radius lies at about 4 earth radii.

PROPAGATION - Movement of electromagnetic waves through space. An important area of space physics research is concerned with propagation in the near space environment.

UTC TIME - Universal Time, Coordinated. Often referred to as UT. For most practical purposes identical to Greenwich Mean Time (GMT) or "Zulu" time.

VLF - Very Low frequency. Defined as 3 to 30 kHz but sometimes used with wildly different frequency ranges.

WAVEGUIDE - A device or physical arrangement which confines the movement of a wave to a particular path rather than allowing it to radiate in all directions. In the case of VLF radio waves, a waveguide is formed by the reflective properties of earth and the lower regions of the ionosphere.

WWV, WWVH - National Institute of Standards and Technology standard time and frequency transmissions on 2.5, 5, 10, 15 and 20 MHz. UTC time is given at the commencement of every minute.

RESOURCES

CONSTRUCTION

"GETTING STARTED IN ELECTRONICS" by Forrest M. Mims, III. Radio Shack (#276-5003) \$2.49. A good introduction that will help you to build and understand the whistler receiver. Other, more specialized booklets by Mims will help the beginner to learn more about particular subjects. They are available at Radio Shack.

THE ARRL HANDBOOK FOR THE RADIO AMATEUR. 1216 pages from The American Radio Relay League. #1670.-\$26.50 including postage. 225 Main Street, Newington, CT-06611. Though primarily devoted to Amateur Radio communications, the "Handbook" covers radio-electronic theory and construction practices with depth and clarity.

COMPONENTS

Many mail-order suppliers of inexpensive components have minimum charges of \$50 or more not helpful if you just need a few- dollars worth of parts. A few sources are more friendly to small orders:

DC Electronics, P.O. Box 3203, Scottsdale, AZ 85271-3203. (Catalog free on request.) No minimum on prepaid orders- \$15 minimum on phone orders. I think you can find I everything to build a good whistler receiver at DC, and lots more besides.

JDR Microdevices, 2233 Branham Lane, San Jose, CA 95124. Catalog - mostly computer stuff but of components too. Wirewrap wire in 500 or 1000 ft quantities is usually a good deal here.

Fair Radio Sales, P.O. Box 1105, Lima, Ohio 45802. Great free catalog. Mostly military surplus, not much in the way of components but lots of test equipment and military communications stuff.

Longs Electronics, 2601 McDavid Court. Birmingham, AL 35210. Free Catalog. Good mail/telephone order source for bulk tape, audio equipment, Marantz recorders.

Mouser Electronics, 11433 Woodside Ave., Santee. CA 92071 and 2401 HWY 287 North, Mansfield, TX 76063. Excellent catalog, almost everything you need to build anything electronic. High minimum charge but an outstanding stock.

REFERENCES ON VLF PHENOMENA

BOOKS

WHISTLERS AND RELATED IONOSPHERIC PHENOMENA Robert Helliwell, Stanford University Press, 1965. 343P. A good historical and theoretical background, with many excellent illustrations. Extensive bibliography. Out of print, check libraries. Interlibrary loan will get it for you eventually.

UPPER ATMOSPHERE RESEARCH IN THE ANTARCTIC, Edited by L.J. Lanzerotti and C.G. Park. Vol. #29 of the Antarctic Research Series, published by The American Geophysical Union, 1978, ISBN 0-87590-141-7.

VLF RADIO ENGINEERING, A.D. Watt. Pergamon Press, 1967. Extensive chapters on VLF propagation and atmospheric radio noise fields. Another "one of a kind" book - that is very hard to find.

PROBLEMS OF ATMOSPHERIC AND SPACE ELECTRICITY, Samuel C. Coroniti, ED. Elsevier Publishing Co. 1965. The entire proceedings of the Third International Conference on Atmospheric and Space Electricity. Lots of good background on thunderstorms and lightning.

ATMOSPHERIC ELECTRICITY. J. Alan Chalmers. Pergamon Press, 1967. Classic text on the atmosphere as an electrical environment, more good lightning background.

ARTICLES AND PAPERS

"Whistlers" L.R.O. Storey, *SCIENTIFIC AMERICAN*, Feb. 1956. pp. 34-37. Historical background with first-person perspective from the beginning of the modern phase of whistler research.

"Whistler Waves and the Magnetosphere" Helliwell, *THE STANFORD ENGINEER*, Oct. 1982. Good introduction to VLF research, with emphasis on Antarctic experiments.

"Sun Storms" Jay Stuller, *AIR AND SPACE/Smithsonian*, June/July 1991 (Vol. 6 N02) P. 50. Nice description of solar monitoring work at the Space Environment Services Center, Boulder, CO.

"The Dynamic Aurora", Syun-Ichi Akasofu. *SCIENTIFIC AMERICAN*, May, 1989. Good reference on the structure and functioning of the Magnetosphere.

"Sounds of Natural Radio" Michael Mideke, *THE LOWDOWN*. June, Aug., Sept., Nov. 1989. Feb., March, Oct. 1990. April, June, July 1991. This is an ongoing series, combining basic theory with accounts of professional research and amateur ventures into the realm of natural VLF phenomena.

PERIODICALS

THE LOWDOWN is a monthly Publication of The Longwave Club of America. 45 Wildflower Road, Levittown, PA 19057. \$12 per year. Back issues are available for \$1 each, membership not required for back issue service. If you are interested in monitoring and communications on longwave, *THE LOWDOWN* presents a good cross-section of amateur ties.

SPELEONICS A quarterly publication by the Communication and Electronic Section of the National Speleological Society. \$4 for 4 issues in USA, Canada, Mexico. \$6 elsewhere. Joe Giddens, P.O. Box 891: Camden. AR 71701. (Make checks payable to *SPELEONICS*.) The publication is devoted to underground communications, radio-surveying and other practical electrical stuff related to caving. Most of the action is below 100 kHz.

WESTERN UPDATE (The Western Newsletter For MF, LF and VLF Experimenters.) Available for 29 cent business size SASE's plus \$1 per issue or \$10 per year from: Jim Ericson. 226 Charles Street. Sunnyvale, CA 94086-6063. Mainly by and for "Lowfers" and "Medters" - folks who work with low powered communications systems in the lower part of the radio spectrum.

THE NORTHERN OBSERVER. Available for \$15 (US) per year and 12 self addressed (not stamped) envelopes from: Herb Balfour, 91 Elgin Mills Rd., West. Richmond Hill, Ontario, L4C4M1, Canada. This is a Northeastern counterpart to *WESTERN UPDATE*, about monthly, and packed with information.

INTMINS OBSERVERS

Roster Update

The following is a roster of INTMINS observers including first-time observers. Team number assignments are permanent and will be used to refer to teams in the future. (Unless noted otherwise, all longitudes are West and latitudes are North.)

North American observers:

Team #	Observer	Location	Longitude/Latitude
1.	John Lamb, Jr. East Texas State University	Belton, TX	95° 53' 59" / 33° 14' 49"
2.	Stephen G. Davis	Fort Edwards, NY	73° 29' 30" / 43° 18' 00"
3.	Don Shockey	Oklahoma City, OK	97° 40' 5" / 35° 43' 30"
4.	Mike Aiello	Croton, NY	73° 46' 45" / 40°
5.	Jean-Claude Touzin	St. Vital Quebec	79° 10' / 48° 55'
6.	Bill Pine Chaffey High School	Ontario, CA	117° 41' / 34° 14'
7	Dean Knight Sonoma Valley High School	Sonoma, CA	122° 33' / 38° 21'
8	Mike Dormann	Seattle, WA	123.4° / 47.2°
9	Robert Moloch Eastern Elementary School	Greentown, IN	85° 58' / 40° 28'
10	Bill Taylor INSPIRE	Washington, DC	38° 54' / 77° 2'
11	Mark Mueller Brown Deer High School	Brown Deer, WI	87° 56' / 43° 10'
12	Jon Wallace	Litchfield, CT	73° 15' / 41° 45'
13	Bill Combs	Crawfordsville, IN	86° 59' / 40° 4'
14	John Barry Seeger High School	West Lebanon, IN	87° 22' / 40° 18'
15	Robert Bennett	Las Cruces, NM	106° 44' / 32° 36'
16	Leonard Marraccini	Finleyville, PA	80° 00' / 40° 16'
17	Kent Gardner	Fullerton, CA	117° 48' 30" / 34° 12' 13"
18.	David Jones	Columbus, GA	77° 07' / 35° 00'
19.	Larry Kramer / Clifton Lasky	Fresno, CA	119° 49' / 37° 01'
20.	Barry S. Riehle Turpin High School	Cincinnati, OH	84° 15' / 39° 7'
21.	Phil Hartzell	Aurora, NE	98° 0' / 41° 0'
22.	Rick Campbell	Brighton, MI	83° 50' 2.7" / 42° 16' 43.7"
23.	Jim Ericson	Glacier, WA	121° 57.91' / 48° 53.57'
24.	Paul DeVoe Redlands High School	Redlands, CA	116° 52' / 34° 10'
25	Norm Anderson	Cedar Falls, IA	92° 15' / 42° 20'
26	Brian Page	Lawrenceville, GA	83° 45' / 34° 45'
27	Ron Janetzke	San Antonio, TX	98° 47' / 29° 35'
28	Thomas Earnest	San Angelo, TX	100° 25' / 31° 16'

European observers:

Team #	Observer	Location	Longitude/Latitude
E1	Flavio Gori	Florence, IT	11° 50' 18" E / 43° 50' 18" N
E2	Silvio Bernocco	Torino, IT	7° 12' E / 44° 54' N
E3	Fabio Courmoz	Aosta, IT	7.7° E / 45.7° N
E4	Joe Banks	London, UK	0° / 50° 52' N
E5	Renato Romero	Cumiana, IT	7° 24' E / 49° 57' N
E6	Marco Ibridi	Finale E., IT	11° 17' E / 44° 50' N
E7	Alessandro Arrighi	Firenze, IT	10° 57' 50" E / 43° 43' 21" N
E8	Zeljko Andreic Rudjer Boskovic Institute	Zagreb, Croatia	
E9.	Dr. Valery Korepanov Lviv Center of Institute of Space Research of NASU	Lviv, UKRAINE	24° E / 50° N
E10.	Sarah Dunkin University College London	London, England	0° 02' E / 51° 40' N

New Observers (11/97):

29	Janet Lowry	Houston, TX
	Longitude:	95° W
	Latitude:	29° N
	San Luis Pass,	18 miles west of Galveston, 32 miles south of JSC
	Receiver:	INSPIRE RS-4
	Recorder:	Radio Shack CTR-69 (ALC and VOX - OFF)
	Antenna:	6' whip
	WWV:	
30	Linden Lundback	Watrous, Saskatchewan, CANADA
	Longitude:	105° 22' W
	Latitude:	51° 41' N
	North side of abandoned farm yard in snow covered stubble field	
	Receiver:	INSPIRE RS-4
	Recorder:	Radio Shack CTR 94 with AGC
	Antenna:	7 foot whip
	WWV:	Radio Shack DS-351

Leonid Meteor Shower - Observations and Data

By: Bill Pine
Ontario, CA

On November 17-18, 1998, the annual Leonid meteor shower was predicted to show a high level of activity - a level reached only about every 30 years. Unfortunately for those of us in the United States, the predicted time of maximum meteor activity was in the early afternoon of November 18. The strategy was to observe in the early morning the day before and after the predicted maximum in an attempt to see if there is a VLF signature for meteors. Since meteor observation depends on clear local weather, some observers were not able to see the meteors (this was the case in Southern California!). Many observers did see several meteors and the frequency of their appearance was indeed higher than on other nights. VLF radio recordings were made and the tapes submitted for analysis.

The analysis of the data consisted of making sound files for the times that corresponded to the sighting of bright meteors. As the data and logs were being examined, a serious problem soon presented itself. Some of the logs did not indicate the meteors with enough time accuracy. Ideally, the meteor should be logged to the second. Using the time marks on the data tapes, this would allow the perfect coordination of the visual and radio observations. The logs of some observers were not precise enough to allow interpretation of the VLF signals to be coordinated with the presence of meteors. In any event, there was no signature VLF signal that could be attributed to meteor activity.

Zeljko Andreic of Croatia indicates that some students from his school were in Mongolia for the Leonid maximum and recorded the event using an RS4 receiver. He says they got some interesting results that they will be presenting and publishing this spring. Zeljko has promised to send reprints of the article when it comes out.

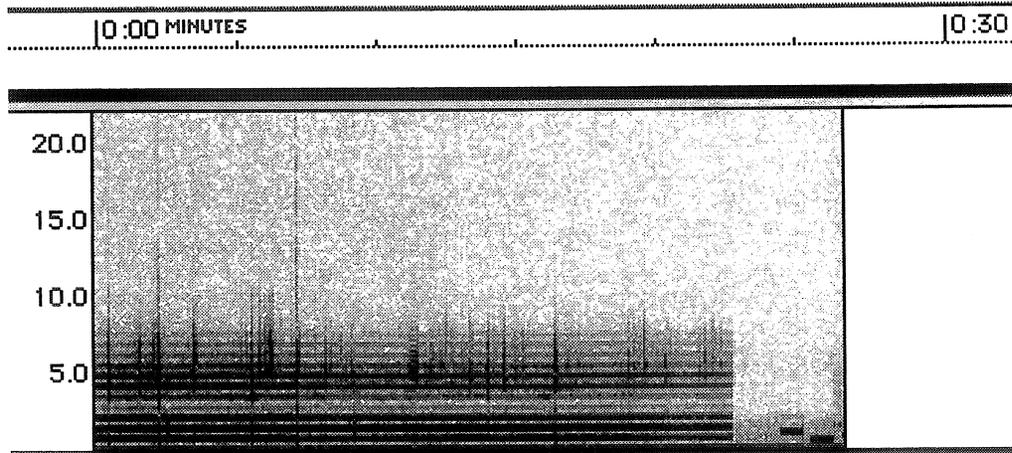
While the maximum was impressive in Mongolia this year, there may be even more meteors next year. As INSPIRE plans for Leonids/99, we will be emphasizing data logging procedures.

The following is a sampler of data recorded by INSPIRE observers last fall. The data analysis procedure was to make 2-minute files at the start of each 12-minute observing period and then to make closeup views corresponding to bright meteors logged.

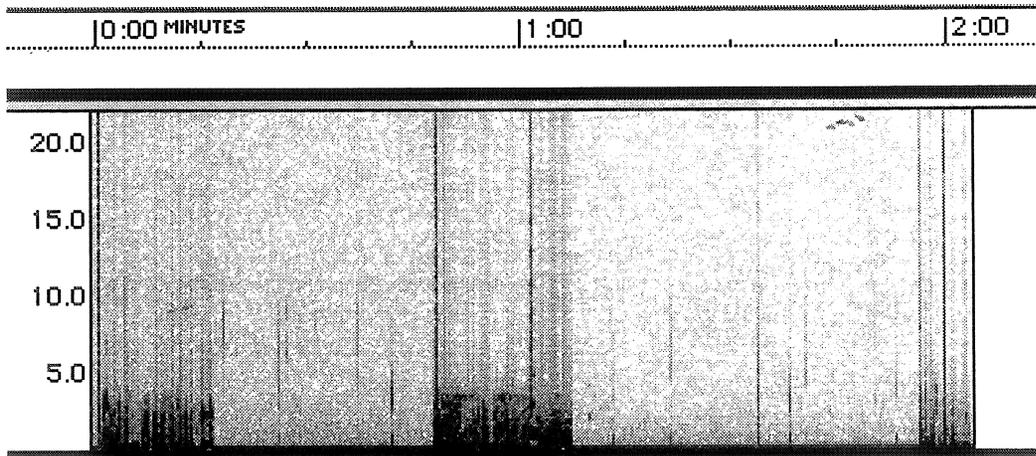
Teams submitting data included:

Team 13	William Combs	Crawfordsville, Indiana
Team 21	Phil Hartzell	Aurora, Nebraska
Team 25	Norm Anderson	Cedar Falls, Iowa
Team 30	Linden Lundback	Watrous, Sask, CANADA
Team E2	Silvio Bernocco	Torino, ITALY

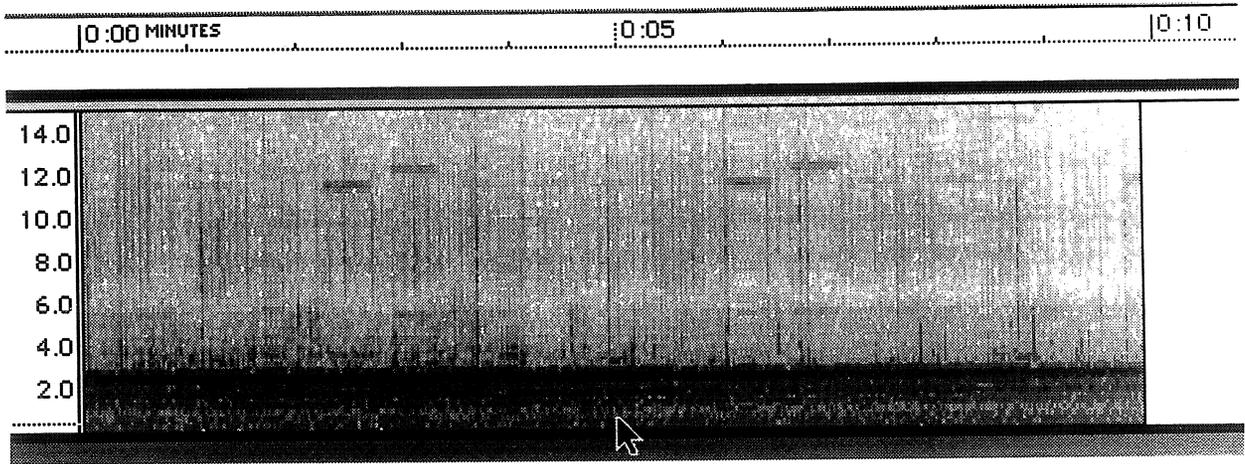
11/17/98



11/17 0900 UT Team 25 Norm Anderson, Cedar Falls, Iowa
Horizontal bars show the strong hum on Norm's tapes during these sessions.
Unknown origin. File ends with 0906 UT WWV tone.

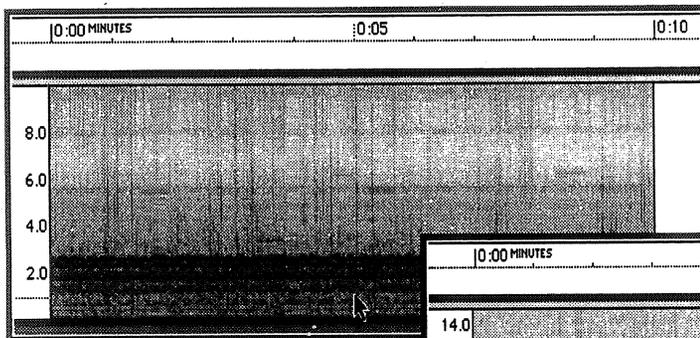


11/17 0900 UT Team 30 Linden Lundback, Watrous, Sask, CANADA
Quiet conditions. WWV time signals shown.

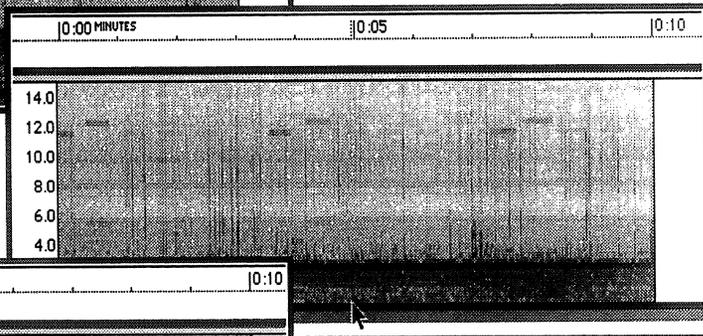


11/17 Team E2 Silvio Bernocco, Torino, ITALY
 10-second file centered on "bolide" (fireball) logged at 043850 UT
 Note the strong Alpha signal and pronounced hum bands below 3 kHz.
 Alpha dashes are visible near 12 kHz; similar dashes at lower
 frequencies are aliases of the strong Alpha signals.

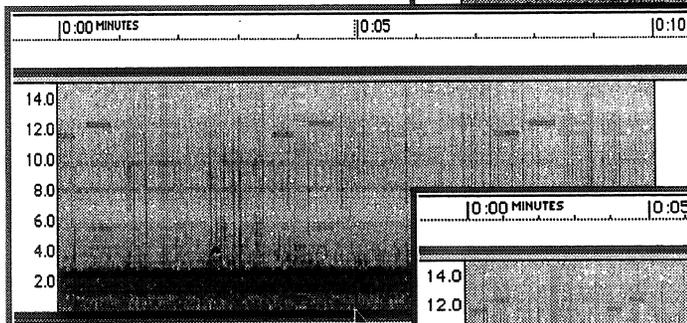
Other meteors logged:



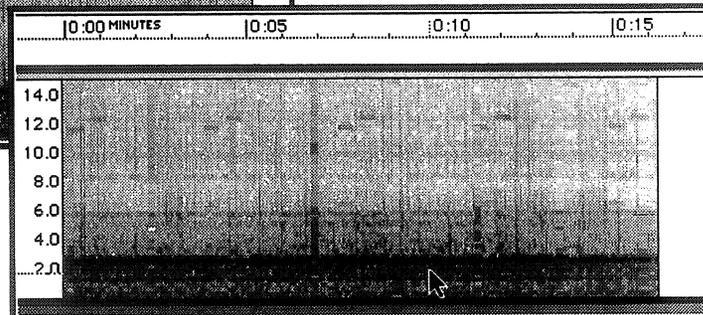
044528 UT



044628 UT

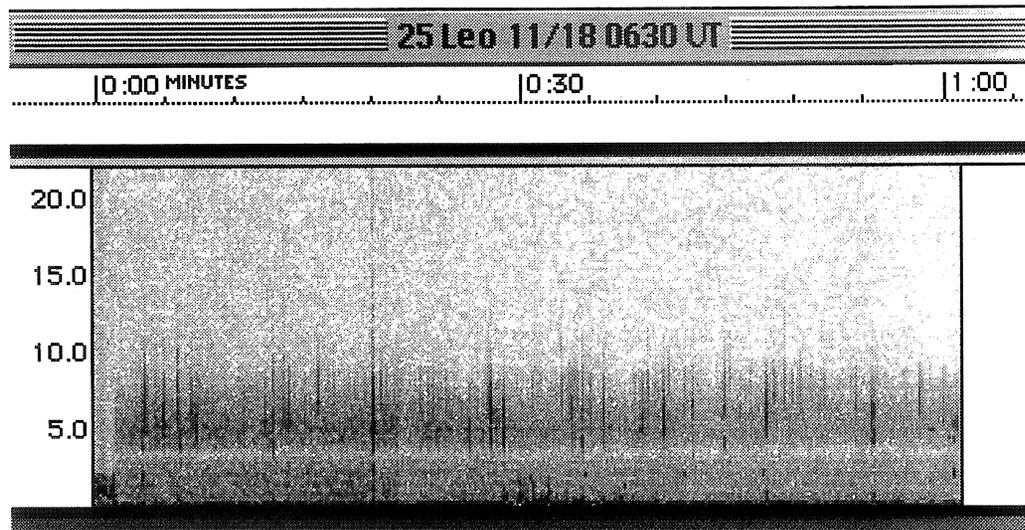


045015 UT

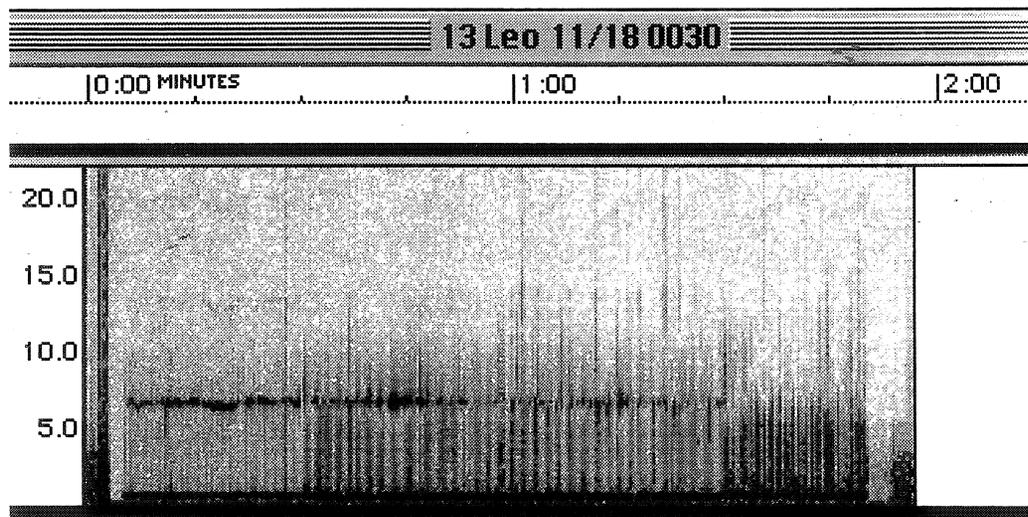


045037 UT

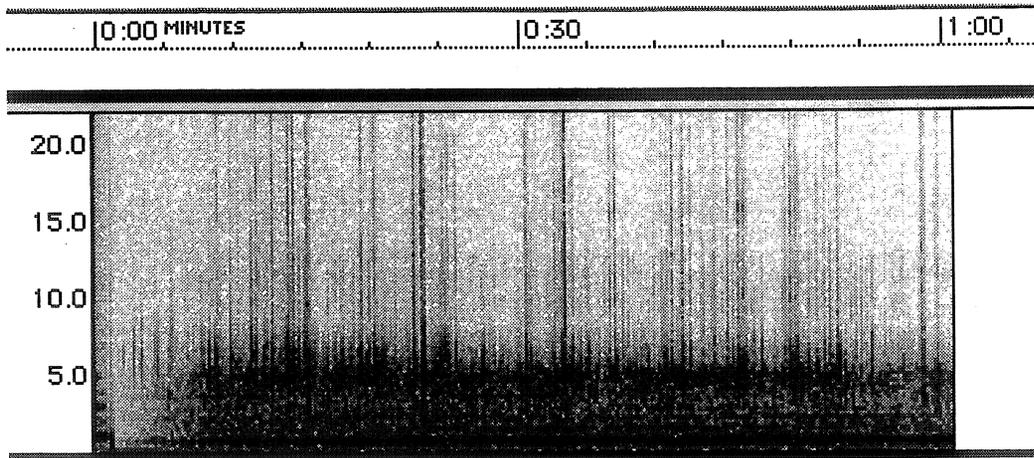
11/18/98



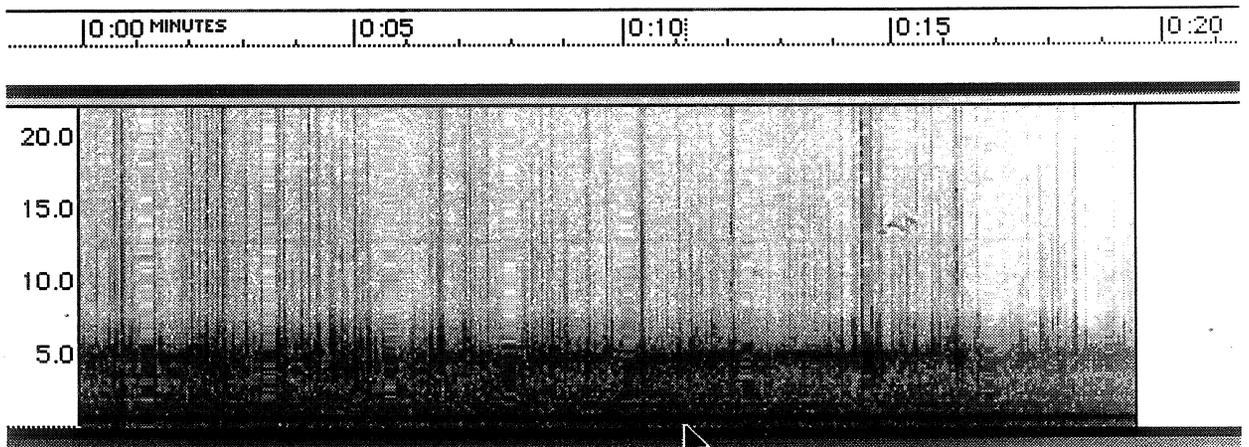
11/18 0630 UT Team 25 Norm Anderson, Cedar Falls, Iowa.
Note that the hum is gone!
Good sferics and tweeks in generally quiet conditions.



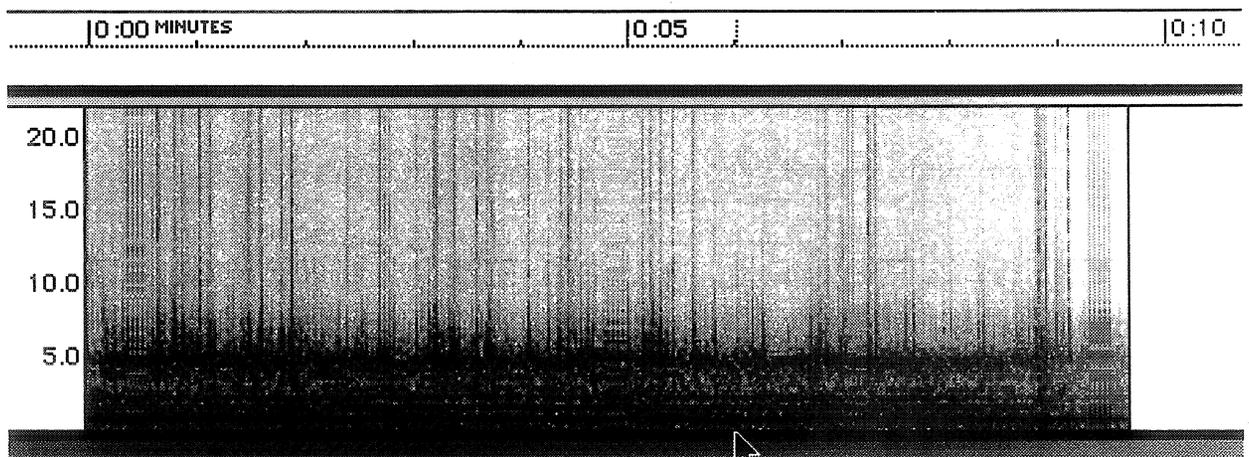
11/18 0530 UT Team 13 William Combs, Crawfordsville, Indiana
There was a persistent but intermittent buzz on the tape and it shows at about 6 kHz.
Strong sferics and tweeks were very evident throughout.



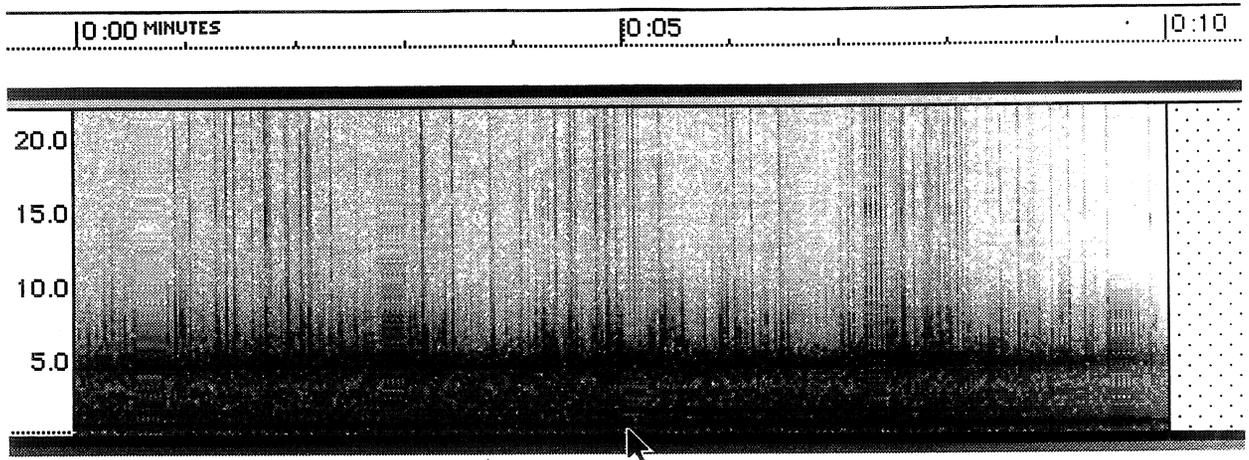
11/18 0704 UT Team 30 Linden Lundback, Watrous, Sask, CANADA
 Generally noisy conditions with good natural VLF reception. Meteor logged at 070441 UT



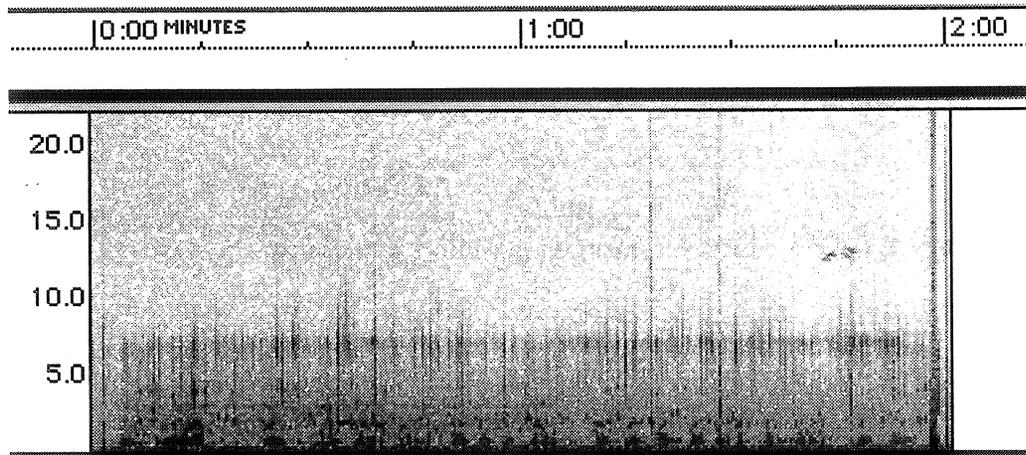
Arrow points to meteor logged at 070441 UT.



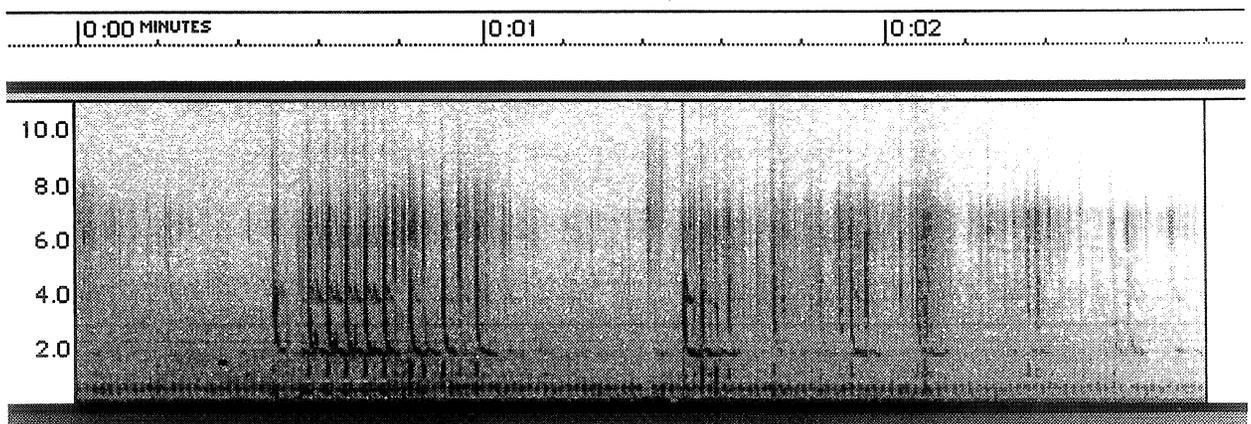
Meteor logged at 073111 UT.



Meteor logged at 073330 UT



11/18 0530 UT Team 21 Phil Hartzell, Aurora, Nebraska



Closeup of tweek burst at about the 7 second point above.
Note the "hook at about 2 kHz and the harmonic at about 4 kHz.

INTMINS - November/98 Data Analysis Report

by Bill Pine
Chaffey High School
Ontario, CA

The November/98 INTMINS observations marked the eighth session in an ongoing series of operations conducted with the cooperation and assistance of the Russian Space Agency (IKI) and ENERGIA, the Russian space engineering organization. INTMINS is an attempt to detect manmade VLF radio waves emitted by instruments on the MIR Space Station.

INTMINS Status Report

Orbital corrections that occurred after the November/98 INTMINS schedule was distributed required a slight modification in the operation schedule. All operations on the first weekend were moved 2 minutes earlier than the scheduled time; all operations on the second weekend were moved 6 minutes earlier than the scheduled time. This resulted in a ground track for all operations that was essentially unchanged from the operations schedule maps. Since these modifications were well within the recording window used in the data taking procedure, there was no need to notify observers of this change. Notification was sent via email to those observers for whom email addresses were on file. The time analyzed on the tapes was, of course, changed to reflect the changed operation of the modulated electron gun, ISTOCHNIK.

The bottom line of the analysis remains unchanged: the VLF signal from the pulsed electron beam was not detected on the ground. This is not an unsurprising result since theoretical calculations of the signal of the power of ISTOCHNIK when propagated to the ground place the signal strength at just about the same as the background of natural VLF. We will continue with INTMINS as long as the Russian Space Agency (IKI) and MIR are able to provide observing opportunities for us. It is beginning to look like (even to an optimist!) the beam strength of ISTOCHNIK is inadequate to propagate a VLF signal to the ground that can be detected by our receivers. In the future, perhaps on the International Space Station, maybe a more powerful electron gun will be available for us to use in this ongoing investigation.

Data Analysis Procedure

The data analysis procedure used consisted of the following:

1. A sound file was created of the 2-minute period of ISTOCHNIK operation.
2. A spectrogram image was made of this file using a frequency range of 0-22.05 kilohertz so that the 12-15 kilohertz range could be examined for the presence of Russian Alpha navigation signals. The 1 kilohertz region of the spectrogram was examined for the 10 seconds on, 10 seconds off signal from ISTOCHNIK.
3. A one-minute portion of the file was cropped, enlarged and an image made using a 0-11.025 kilohertz frequency range. Again the 1 kilohertz region of the spectrograph was examined.
4. Finally, a 30-second portion was cropped, enlarged and an image made. A final examination of the 1 kilohertz region was made.

5. Additional sound files and spectrogram images were made of items of interest noted in the logs.

INTMINS-November/98 Operations Summary

(NOTE: All times are UT on the date indicated.)

European Passes

Pass	ISTOCHNIK Start Time	Path during ISTOCHNIK Firing	Number of Observers Recording Data
E21-5	2036	Central Italy	4
E21-6	2216	Russia, south of Moscow	2
E27-1	1723	Central Italy	1
E27-2	1903	Russia, south of Moscow	1
E27-3	2032	England	1
E28-5	1753	Croatia	2
E28-6	1931	Russia, south of Moscow	1
E28-7	2100	England	1

North American Passes

Pass	ISTOCHNIK Start Time	Path during ISTOCHNIK Firing	Number of Observers Recording Data
21-1	0107	East of NC, VA, DC, MD	1
21-2	0241	IL, IN, MI	1
21-3	0410	Central CA	4
21-4	0533	WA, ID	2
22-1	0130	SE of TX, LA	2
22-2	0302	So. CA, AZ	3
22-3	0439	OR, ID	2
27-4	2324	TX	2
28-1	0057	So. CA	1
28-2	0241	Quebec	2
28-3	0551	MN, IA, IL, IN	1
28-4	0721	WA, OR	0
28-8	2222	DC, MD, DE NJ, NY	1
28-9	2351	NM	3
29-1	0125	No. CA	2
29-2	0309	Quebec	2
29-3	0443	MN, WI, MI	1
29-4	0621	MS, AL, FL	2

Summary of European Passes Recorded

Team/Pass	E21-5	E21-6	E27-1	E27-2	E27-3	E28-5	E28-6	E28-7
E1	x					x		
E2	x					x		
E5	x	x	x	x			x	x
E6	x	x			x			

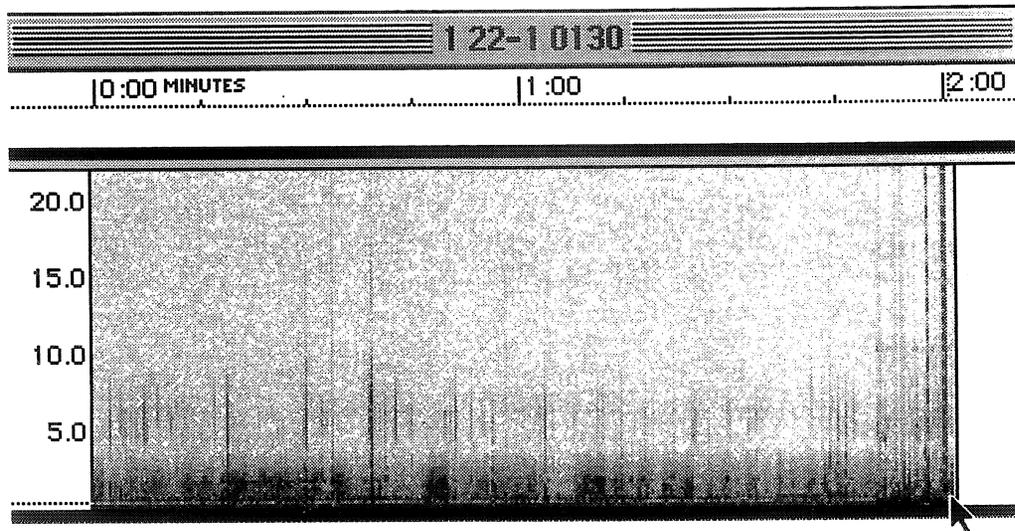
Summary of North American Passes Recorded

Pass	11/21				11/22				11/27	11/28					11/29					
	1	2	3	4	1	2	3	4		1	2	3	4	8	9	1	2	3	4	
Team																				
1	x						x		x						x					
4														x						
5											x						x			
6			x			x			x											
7			x				x									x				
15			x	x	x	x	x								x	x	x	x	x	x
18																				x
25		x										x								
28					x			x							x					
30			x	x							x									

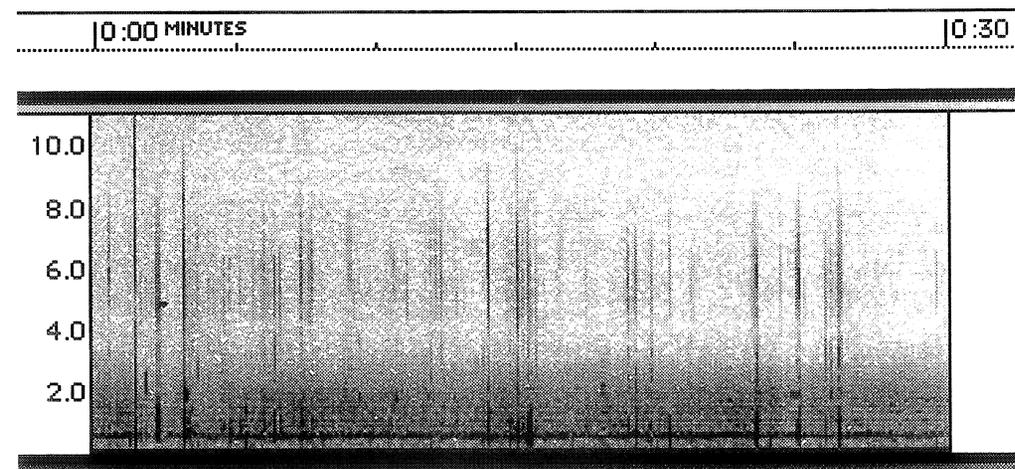
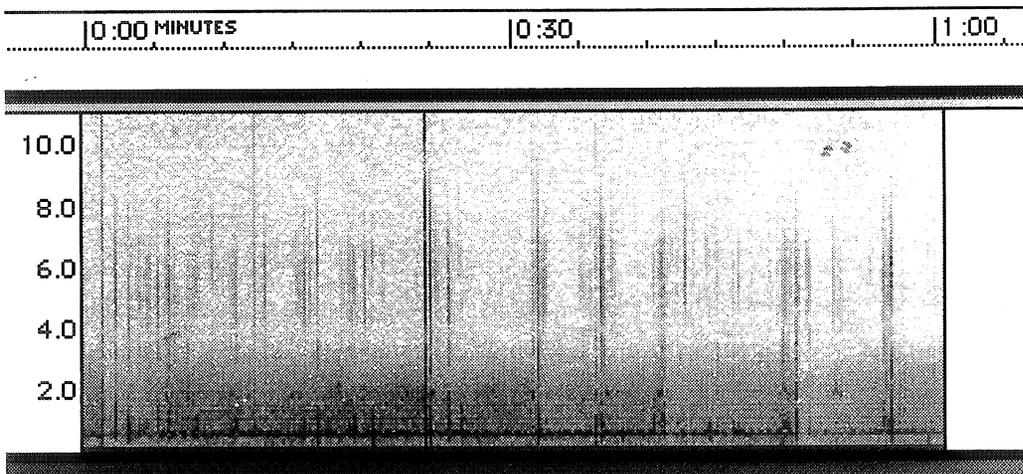
INTMINS Data

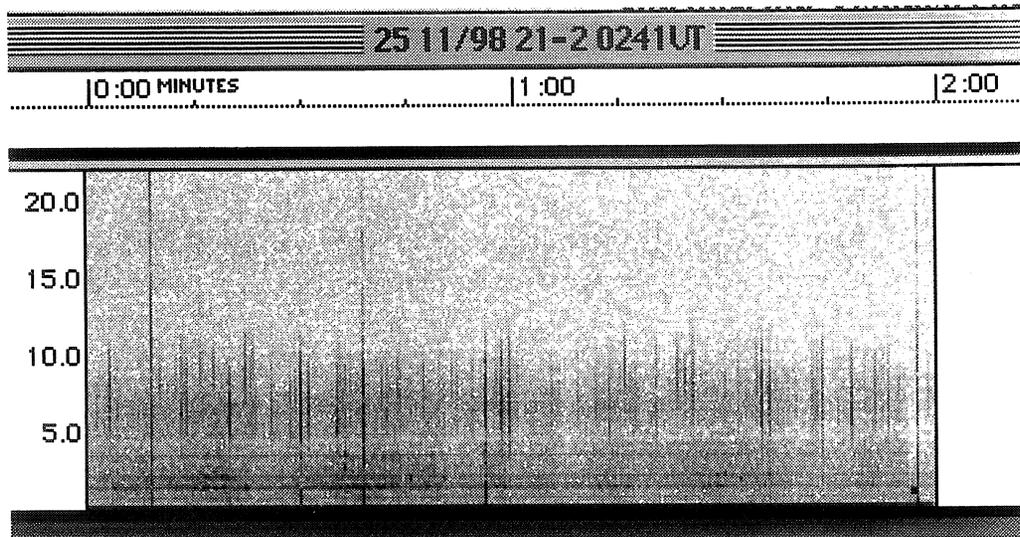
The following spectrograms are taken from data tapes submitted by INSPIRE observers. The first view shown will be that of the entire two-minute interval analyzed. At the top of the image is the sound filename which consists of the Team Number, operation number, and the start time of the operation. Subsequent views will be of portions of the first. Use the time scale at the top to determine the length of the view. Use the frequency scale on the left to determine the frequency range used for that view. Unless otherwise noted, the start time of the cropped view is the same as the start time of the operation.

21-1

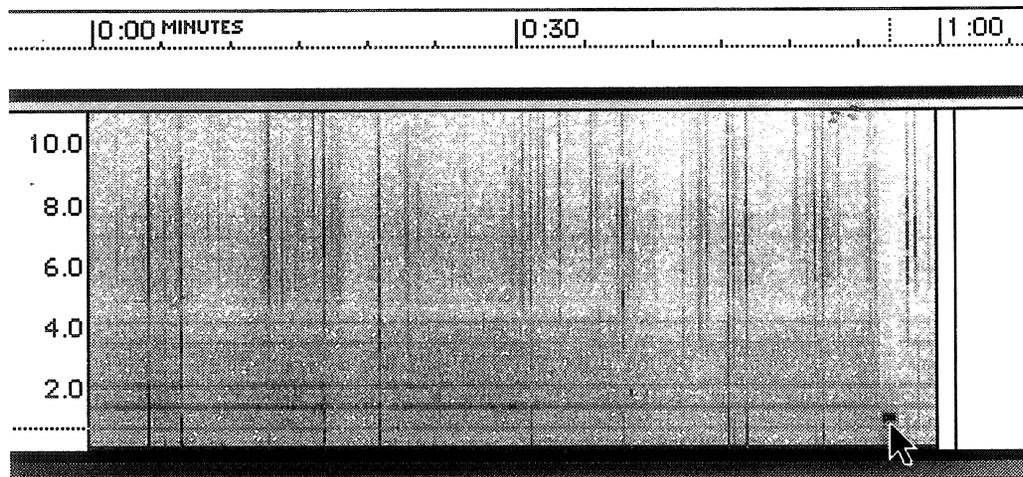


Team 1 Jack Lamb, Belton, Texas. Very low hum level with good sferics. Arrow: 0132 UT

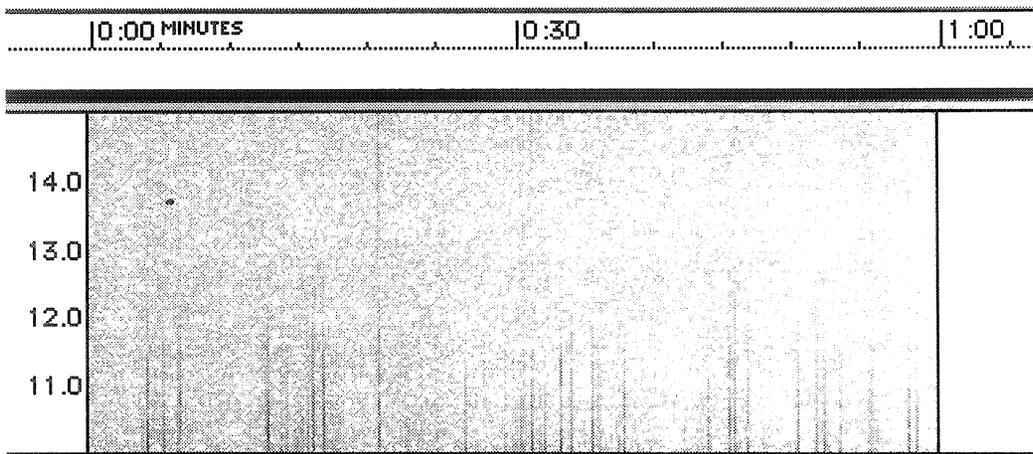




Team 25 Norm Anderson, Cedar Falls, Iowa. Some hum present, but sferics stand out against this low level background. Medium density sferics and tweaks.

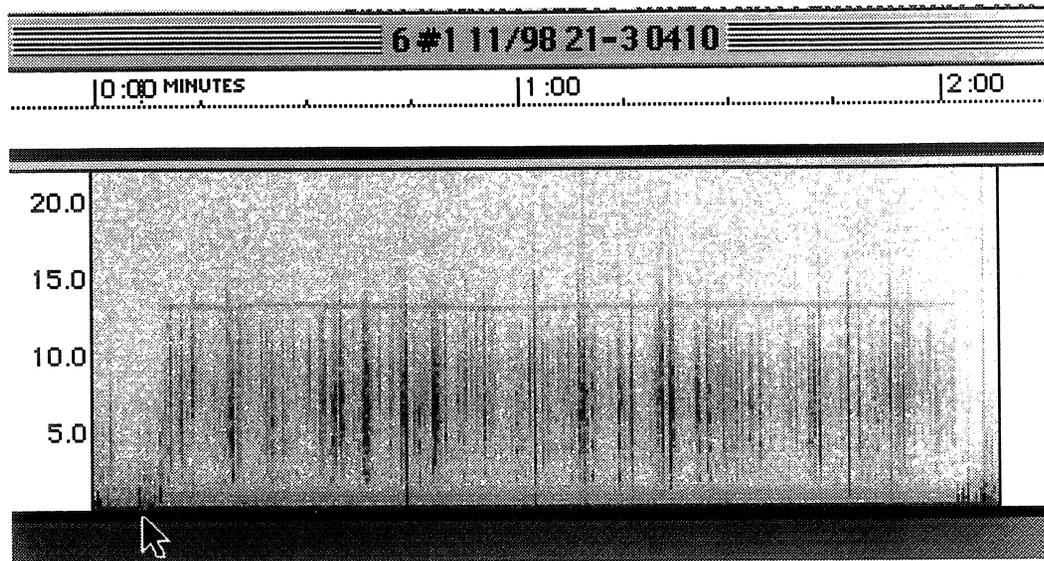


Last minute from above. Arrow points to WWV tone at 0243 UT.

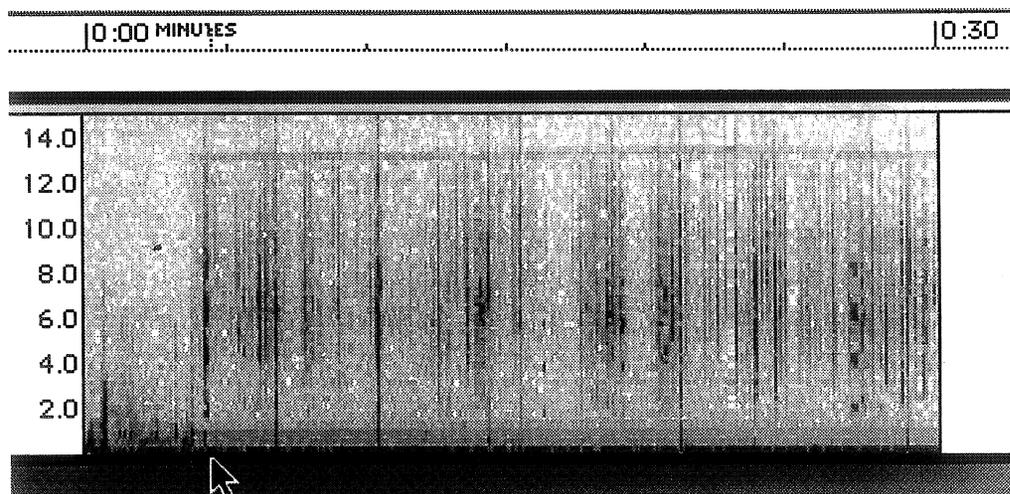
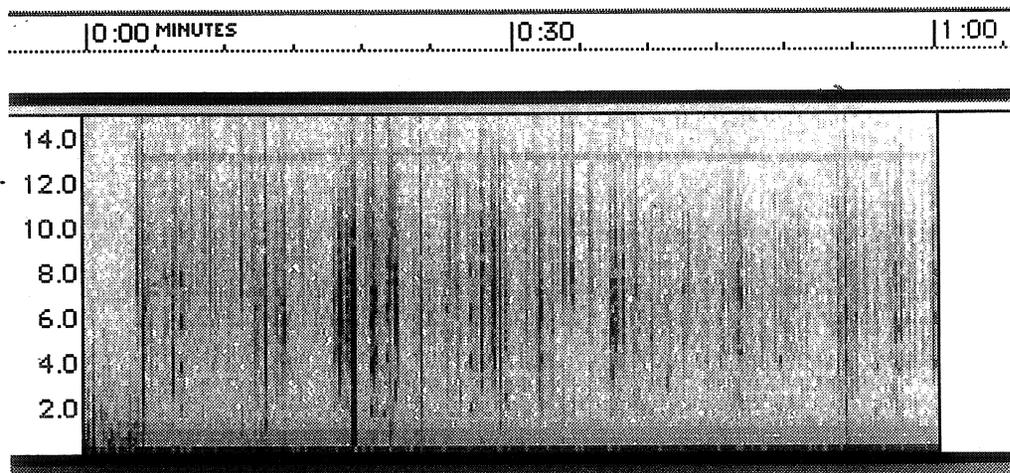


The last minute using 10-15 kHz range to look for Russian Alpha signals. None seen.

21-3

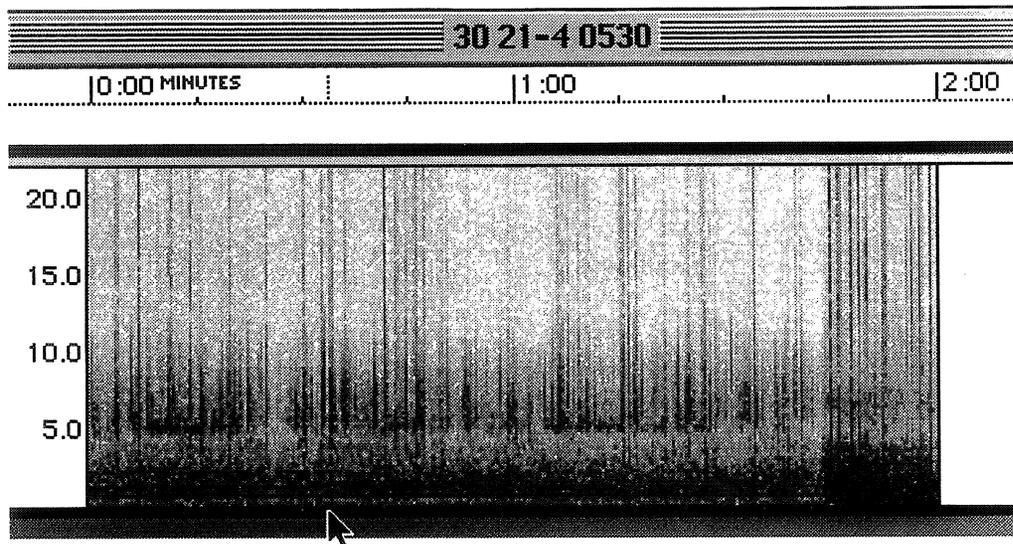


Team 6. Bill Pine, Chaffey High School, Ontario, California. Arrow points to 0410 “mark”. Dense sferics and tweeks.

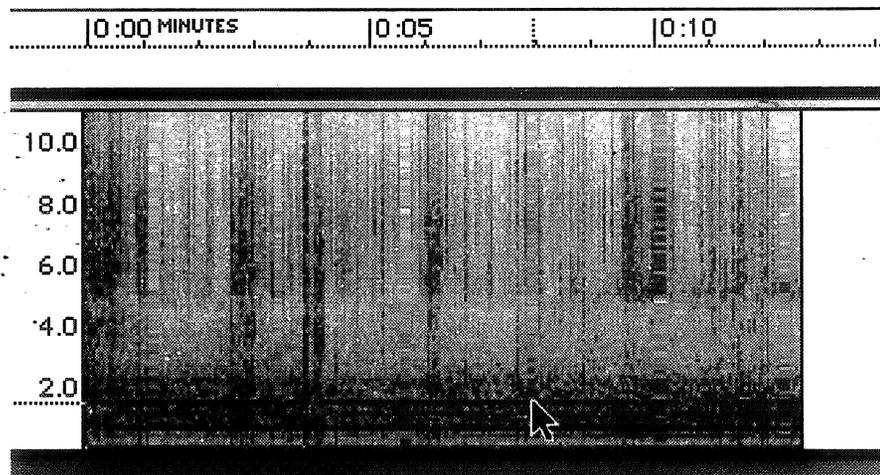


The arrow points to a strong tweek with a “hook” at about 2 kHz and several harmonics present.

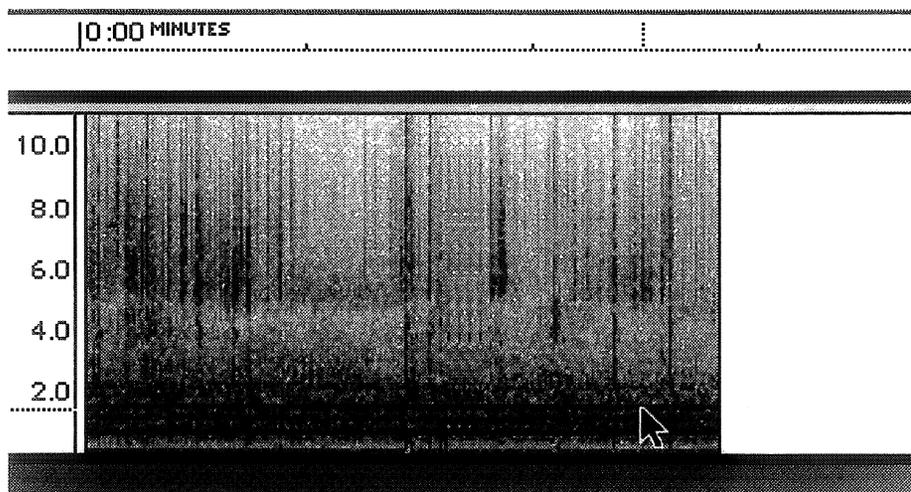
21-4



Team 30. Linden Lundback, Watrous, Saskatchewan, CANADA. Arrow points to whistler logged at 0530:35 UT.

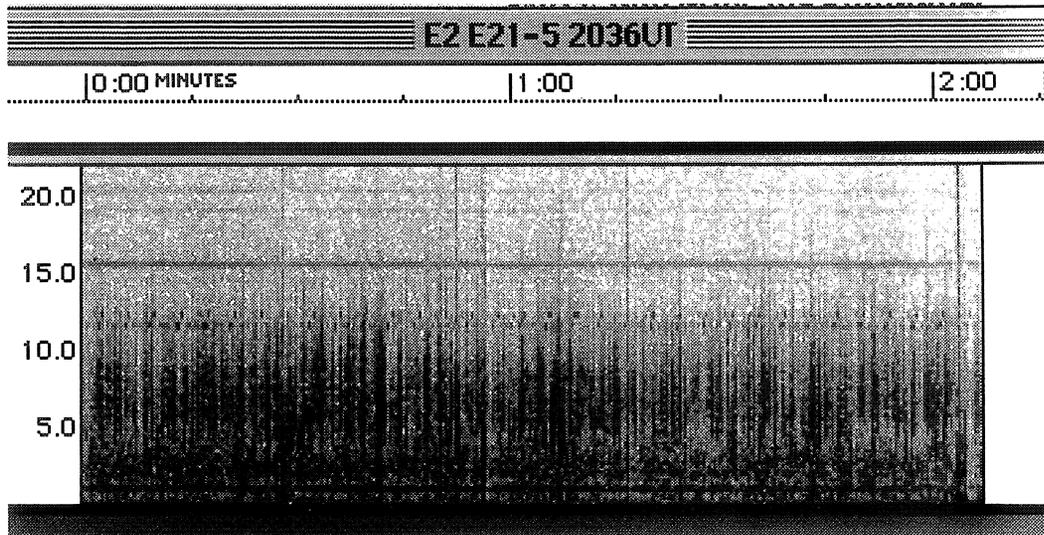


Arrow points to whistler.

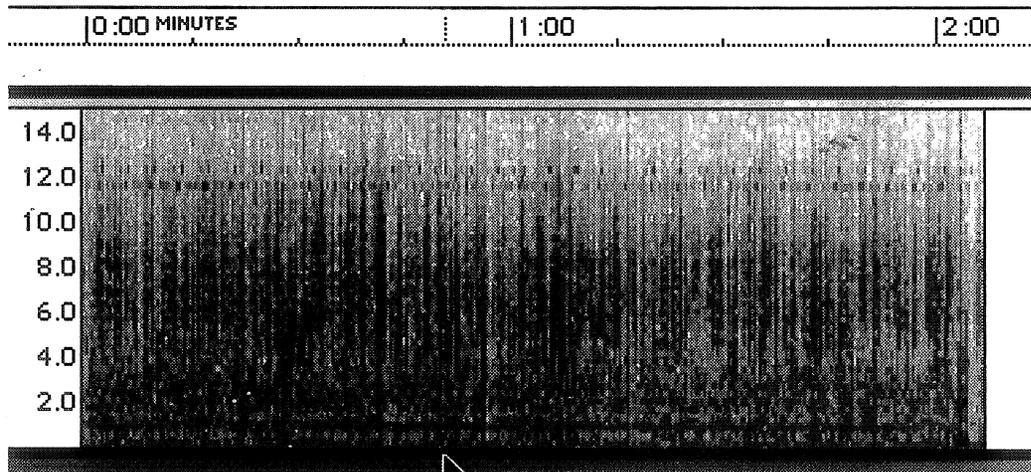


Arrow points to whistler. Not as obvious in this extreme closeup.

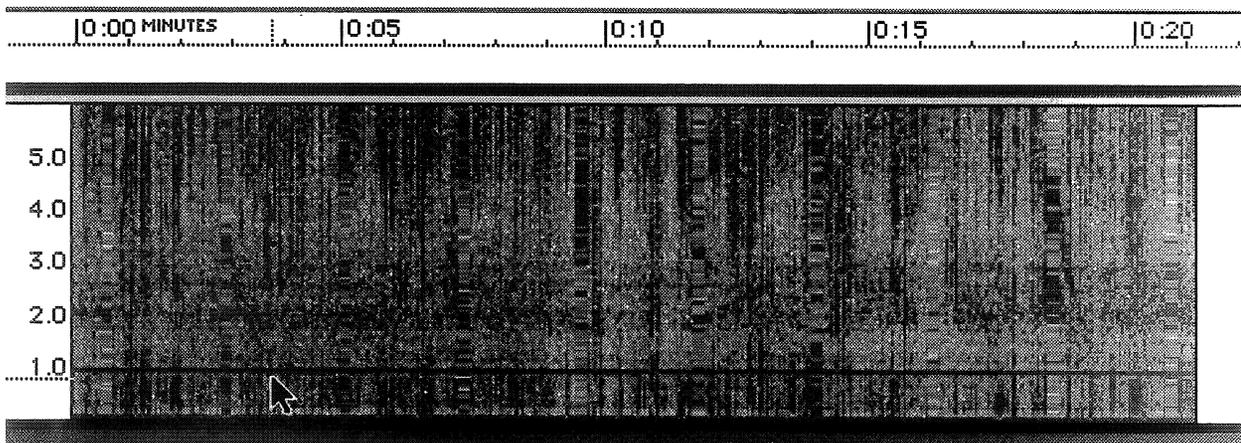
E21-5



Team E2. Silvio, Bernocco, Torino, ITALY.

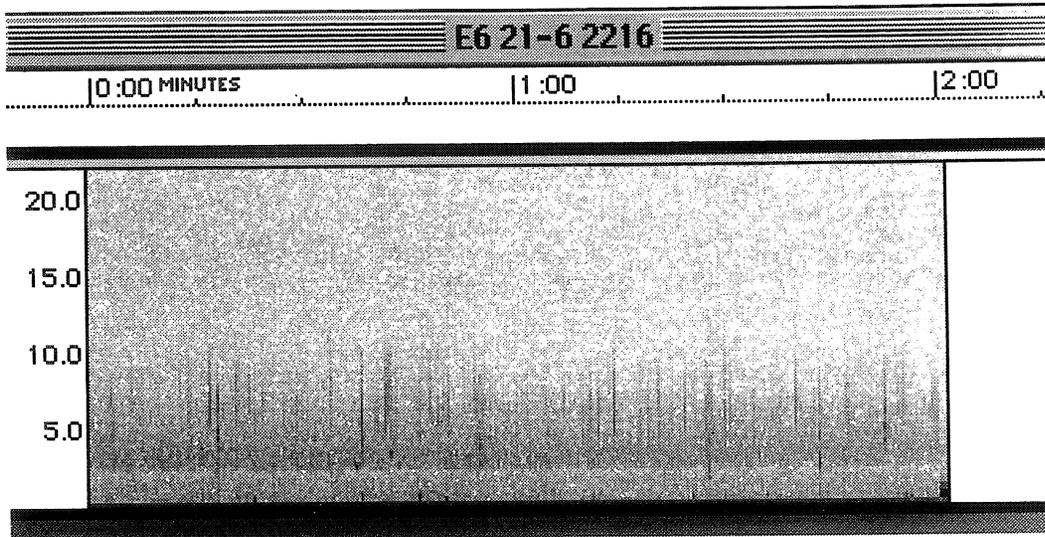


Arrow indicates whistler logged at 2036:45 UT. Note strong Alpha at and above 12 kHz.

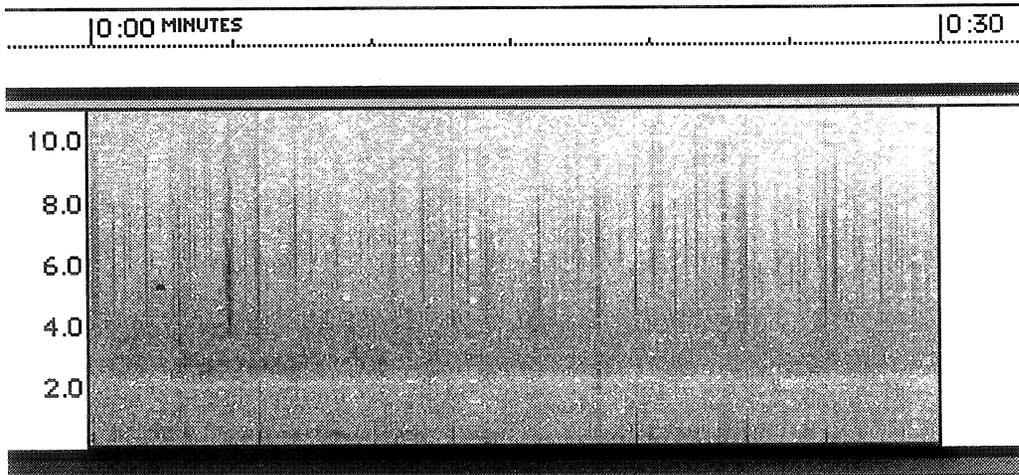
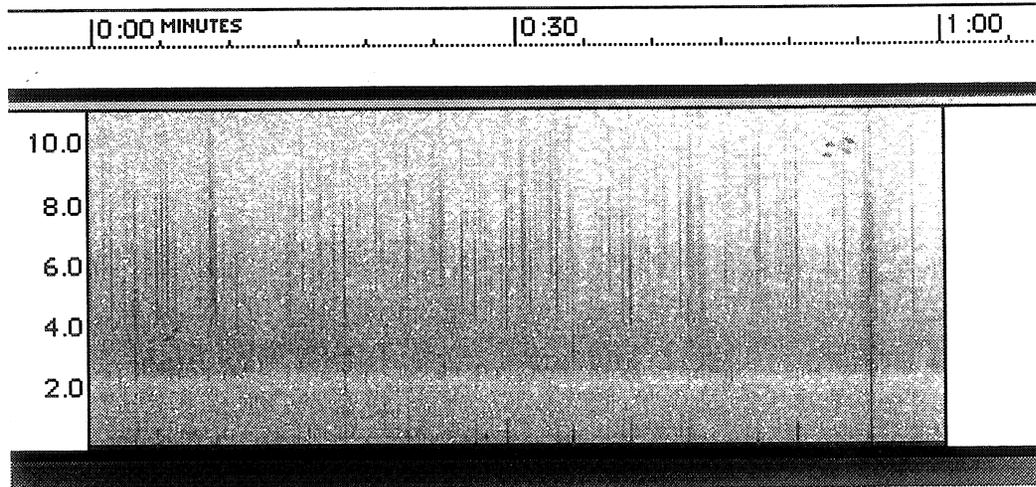


Arrow indicates weak whistler; strong whistler is visible at :18 seconds.

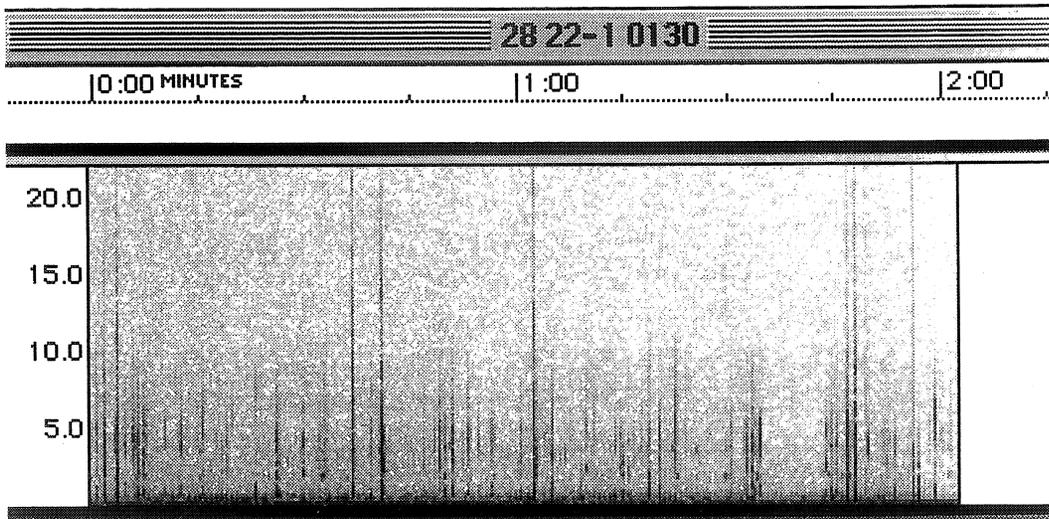
E21-6



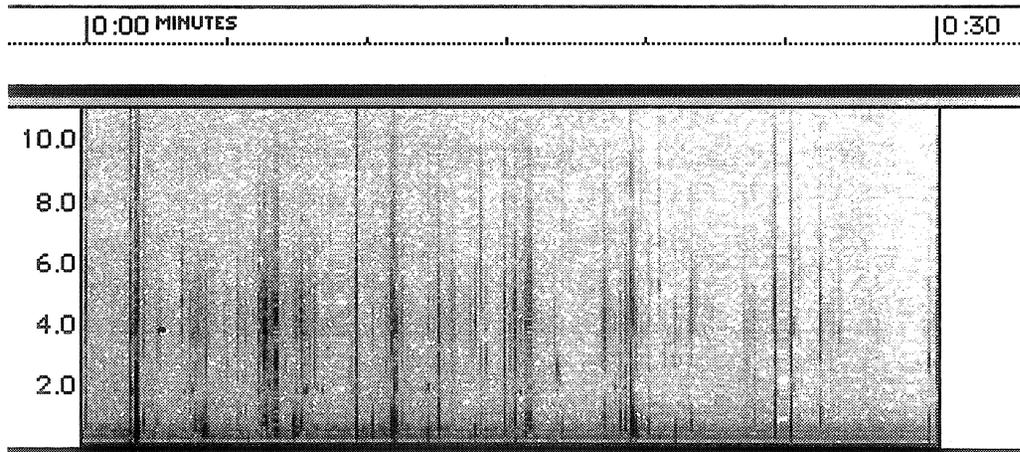
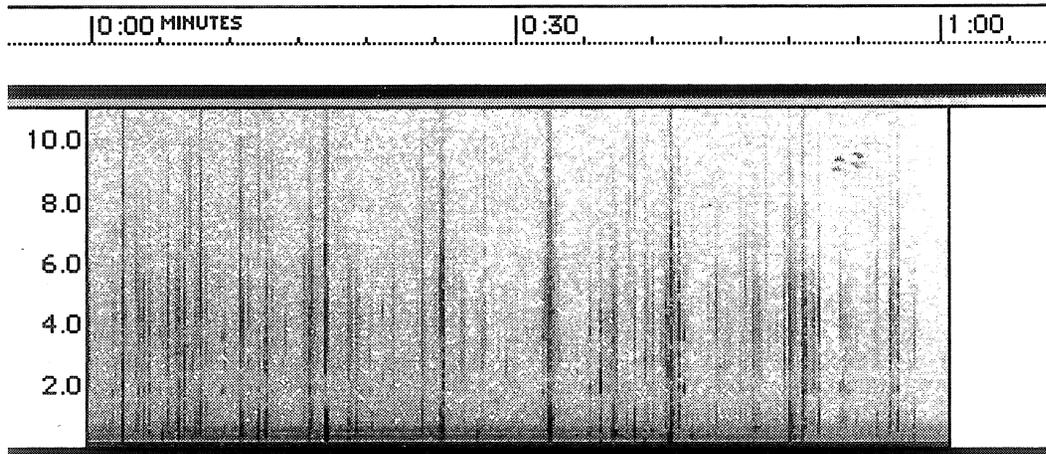
Team E6. Marco Ibridi, Finale E., ITALY.



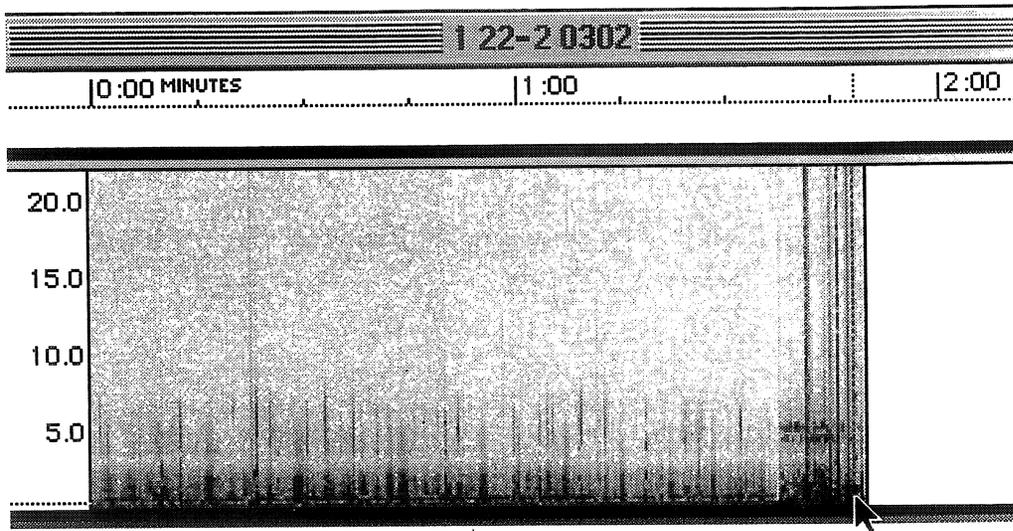
22-1



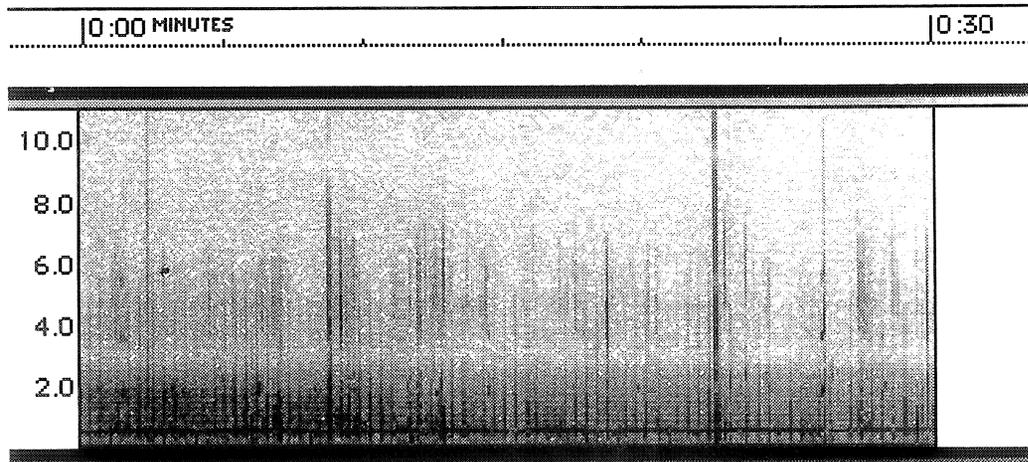
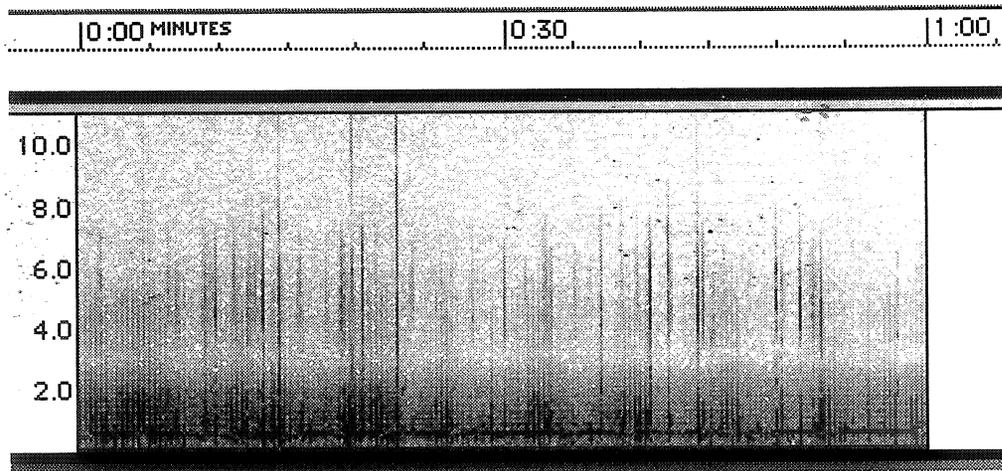
Team 28. Thomas Earnest, San Angelo, Texas.



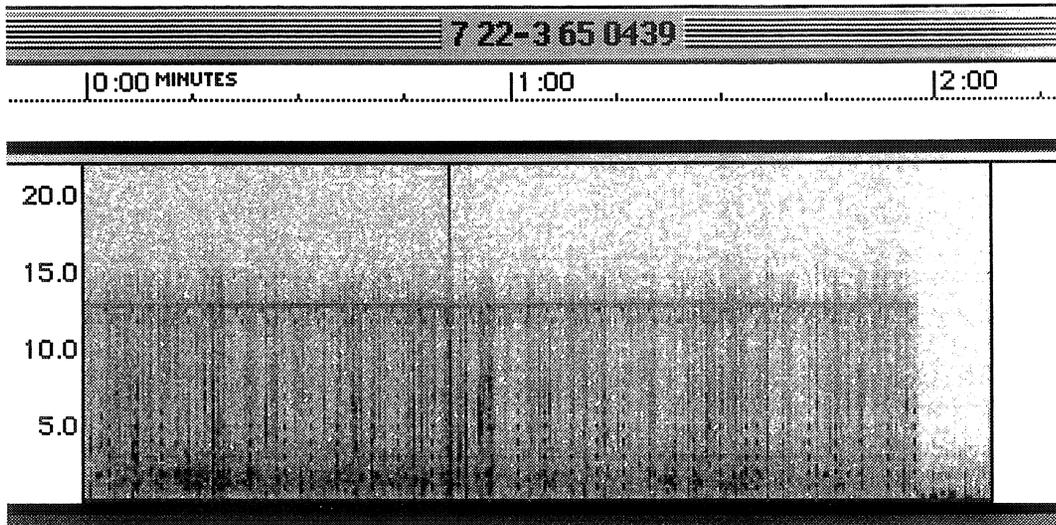
22-2



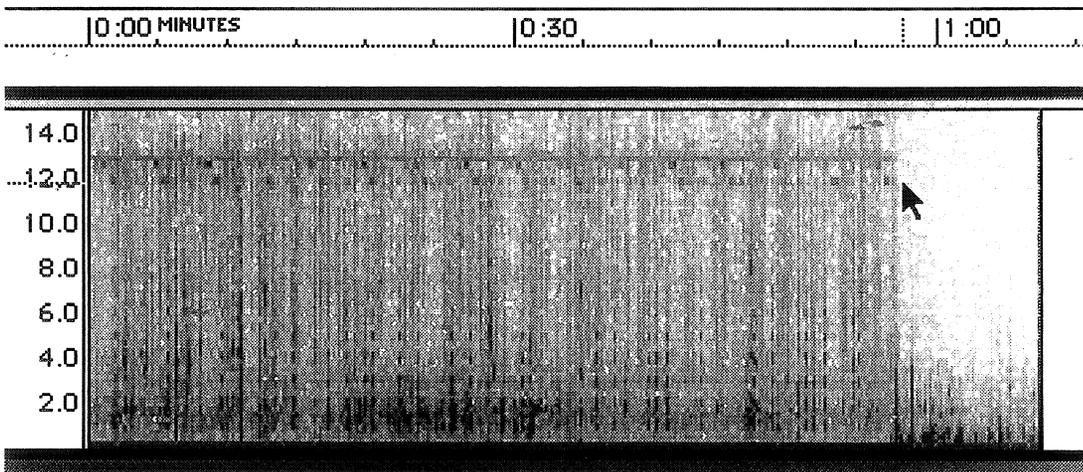
Team 1. Jack Lamb, Belton, Texas. Arrow points to 0304 WWV tone. Computer was started a little late resulting in a file less than 2 minutes long.



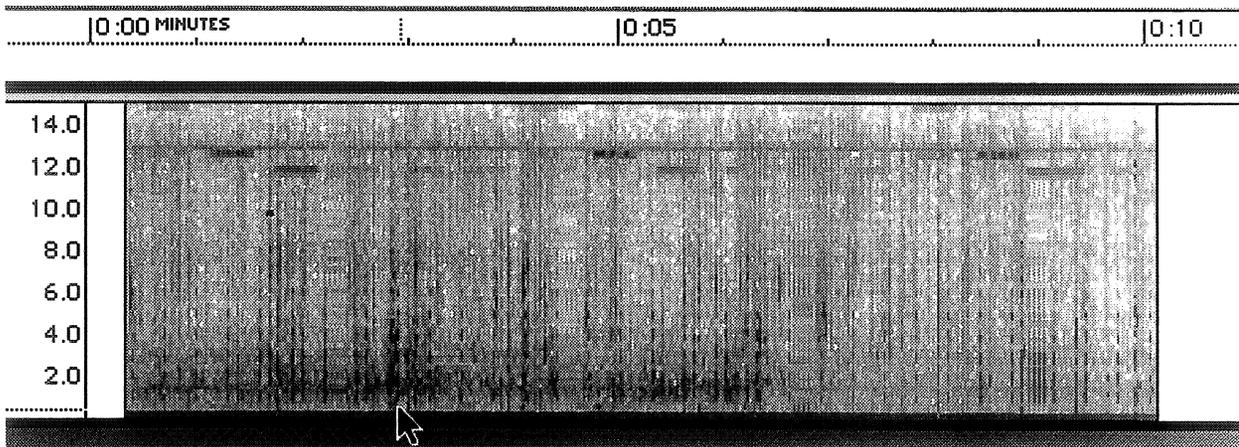
22-3



Team 7. Dean Knight, Sonoma Valley High School, Sonoma, California. Dense sferics. Alpha signals evident between 10 and 15 kHz.

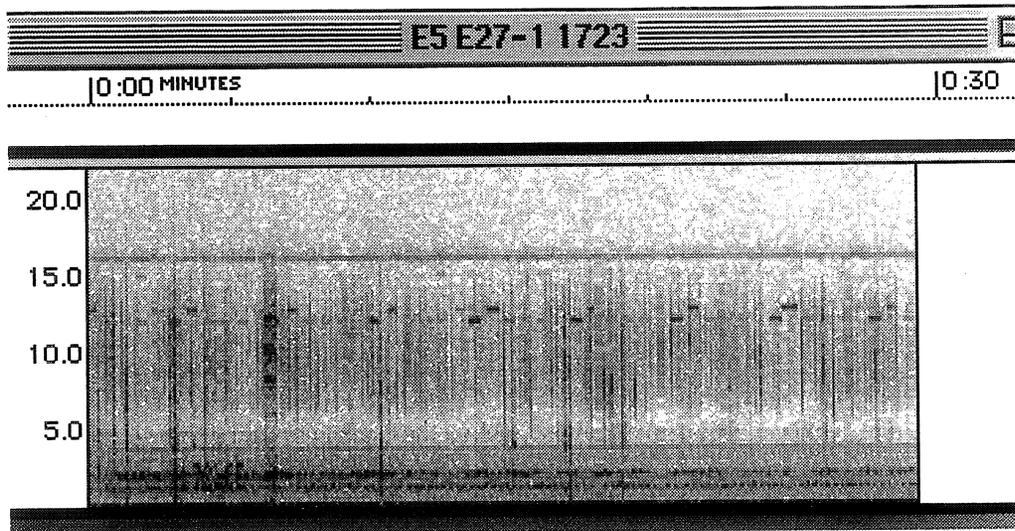


Arrow points to the region of dashes indicating the presence of Russian Alpha navigation signals.

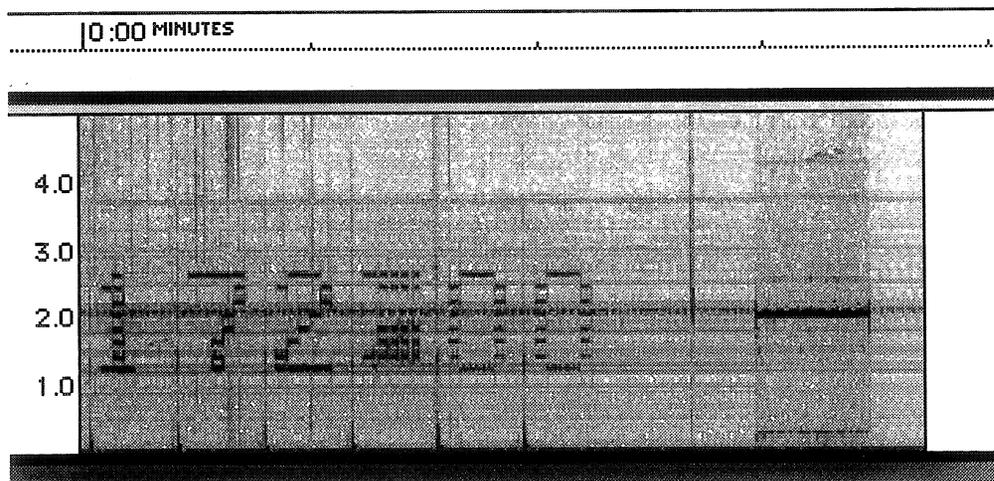


First 10 seconds showing the Alpha pattern. Arrow indicates a strong tweek.

E27-1

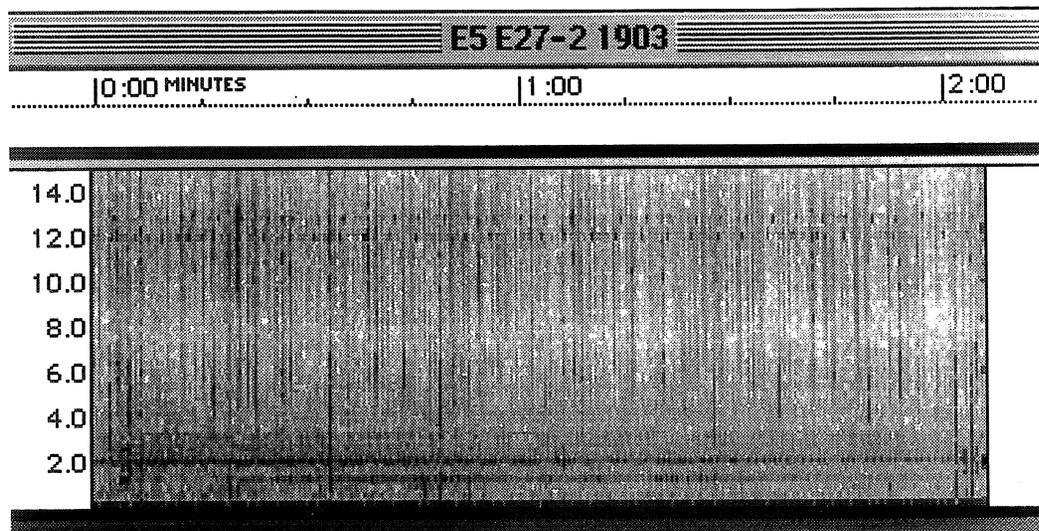


Team E5. Renato Romero, Cumiana, ITALY. First 30 seconds. Note the strong Alpha signal.

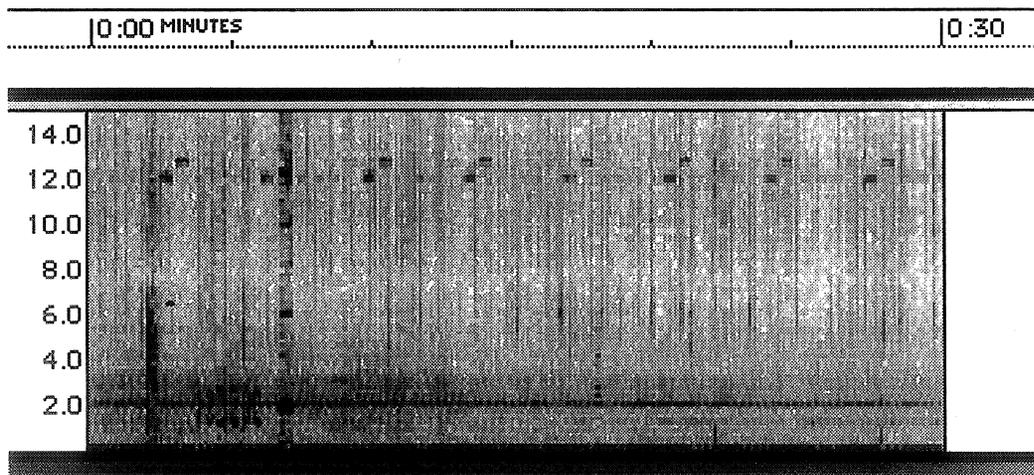
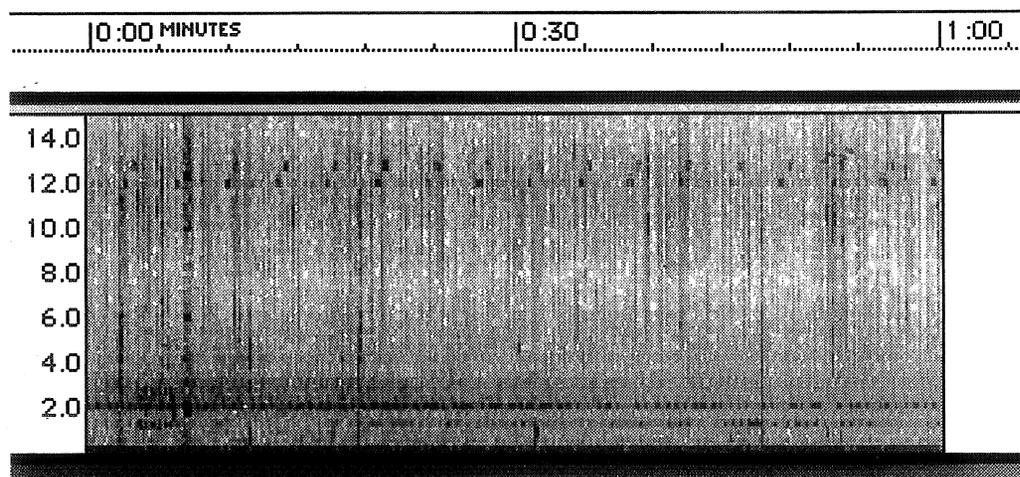


This is a closeup of the automatic time stamp from Mike Aiello's software. This sounds on the tape like a musical ringing and appears on the spectrogram as seen above.

E27-2

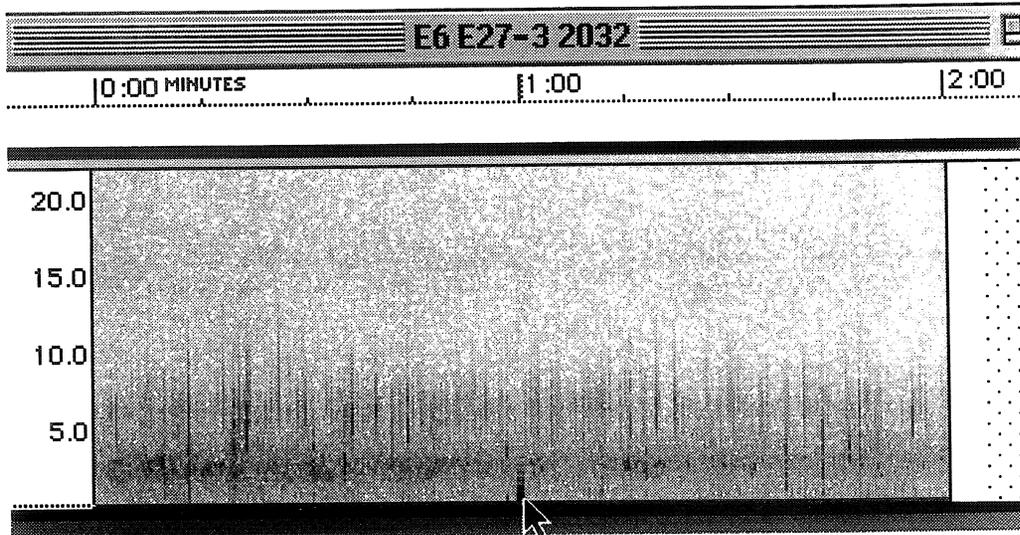


Team E5. Renato Romero, Finale E., ITALY.

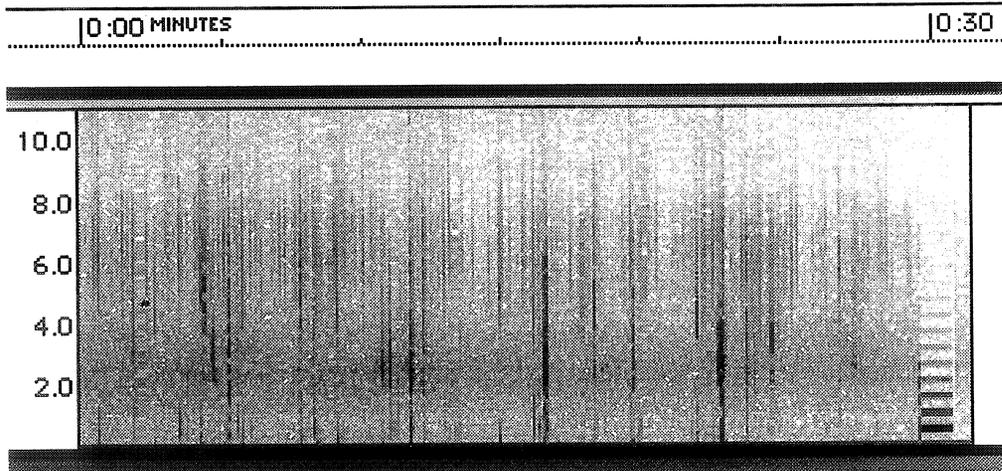
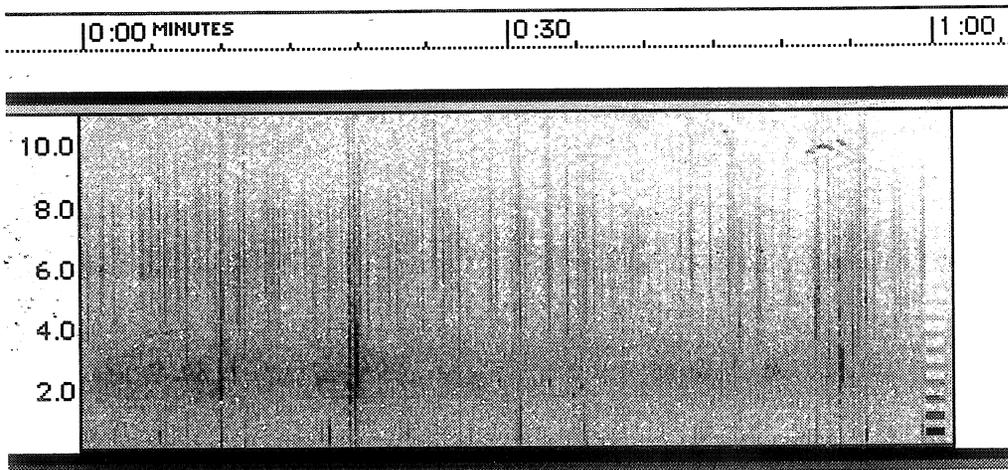


Note the strong Alpha signals.

E27-3

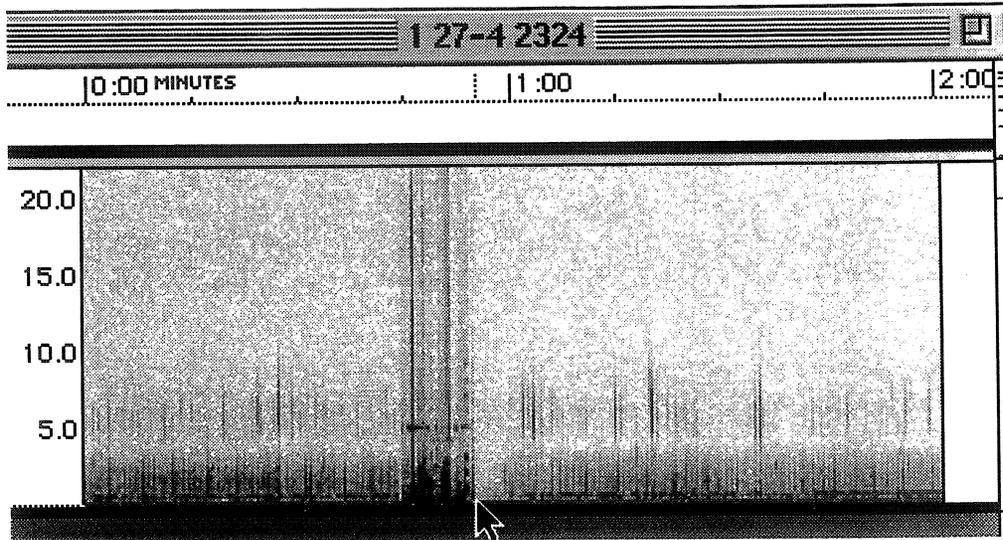


Team E6. Marco Ibridi, Finale E., ITALY. Arrow points to 2033 UT time mark.

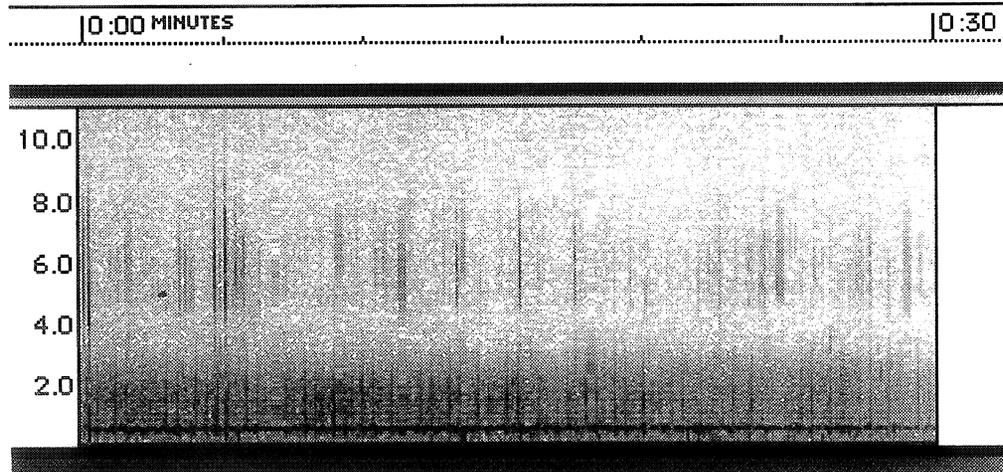
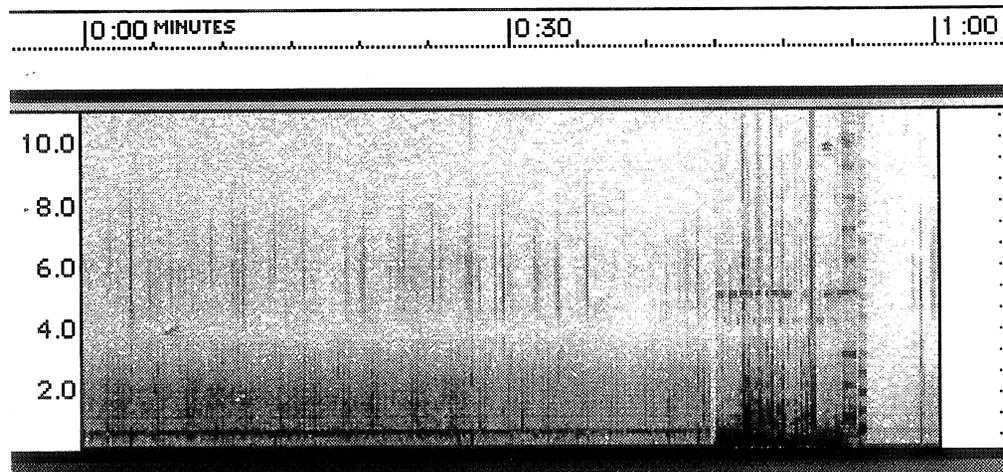


Last 30 seconds from above. Note the harmonics on the time tone.

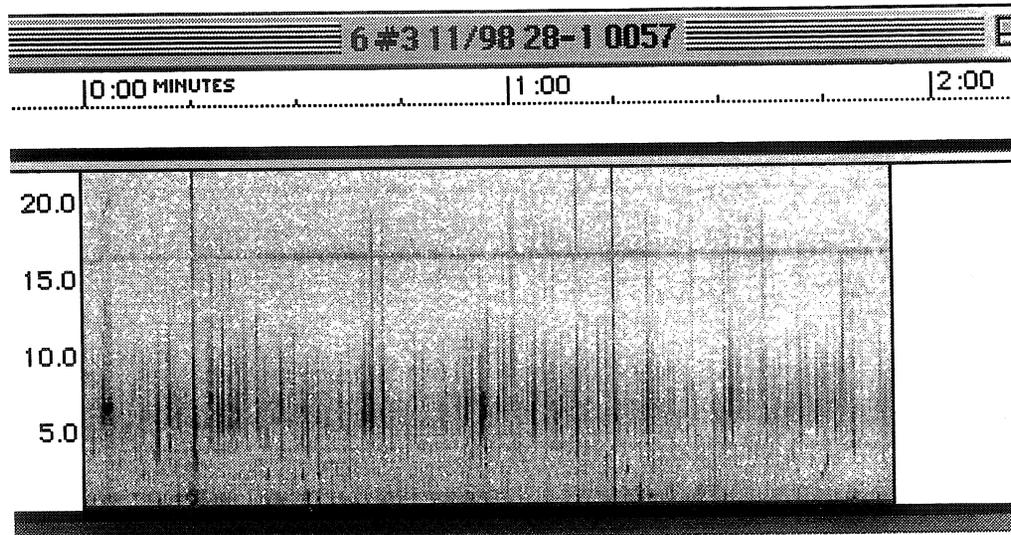
27-4



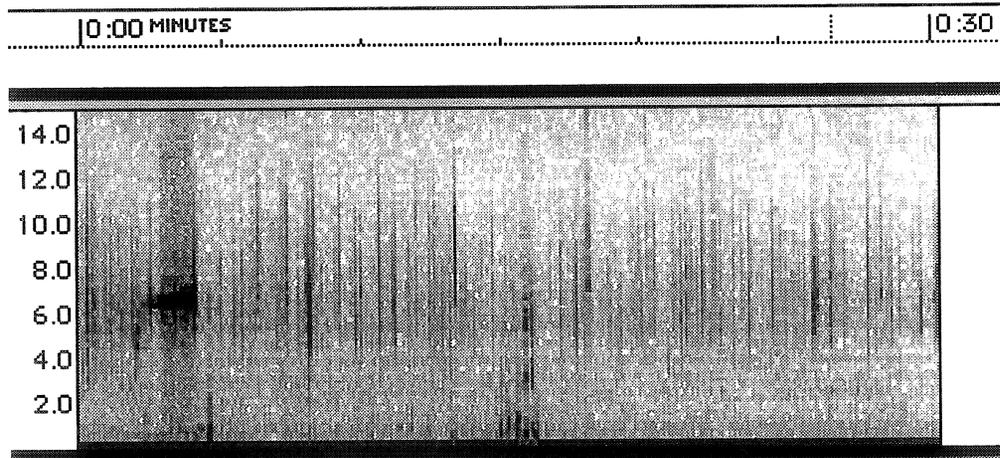
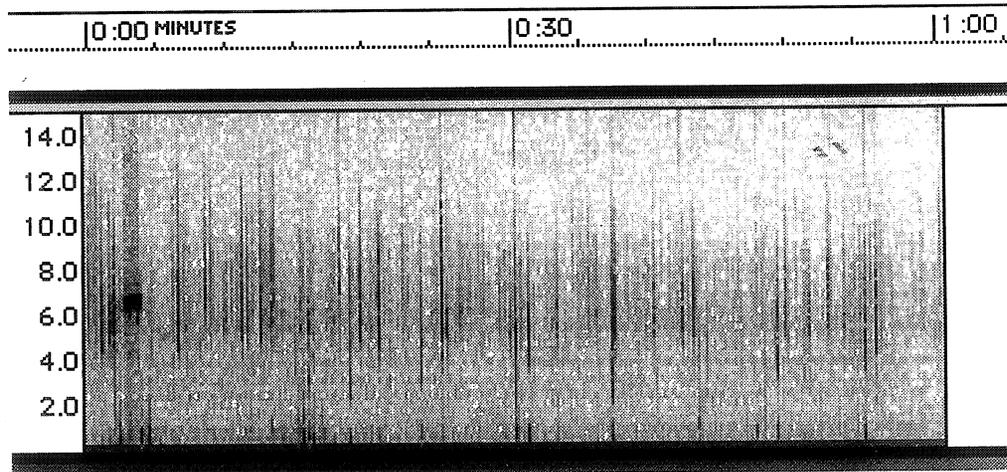
Team 1. Jack Lamb, Belton, Texas. Arrow points to 2325 UT WWV tone.



28-1

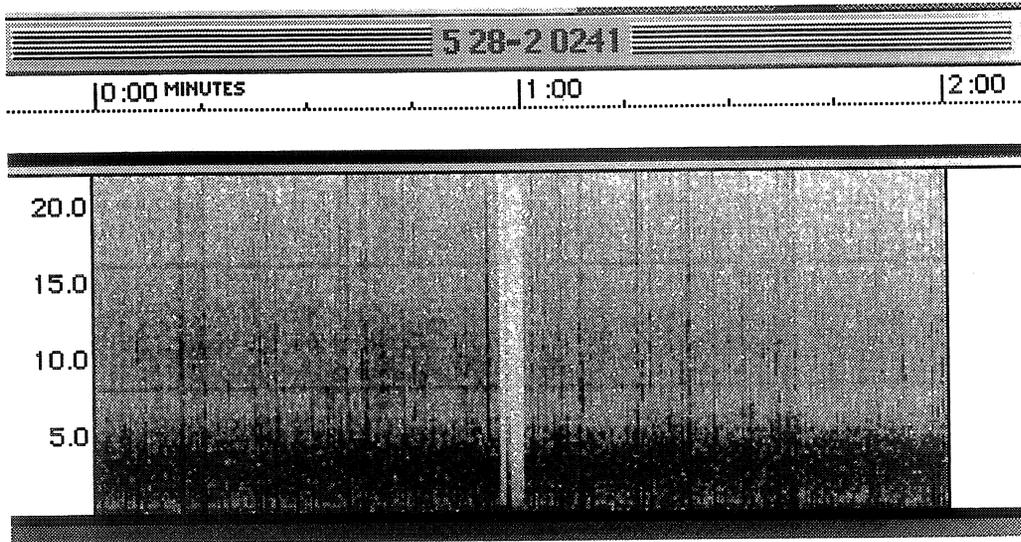


Team 6. Bill Pine, Chaffey High School, Ontario, California.

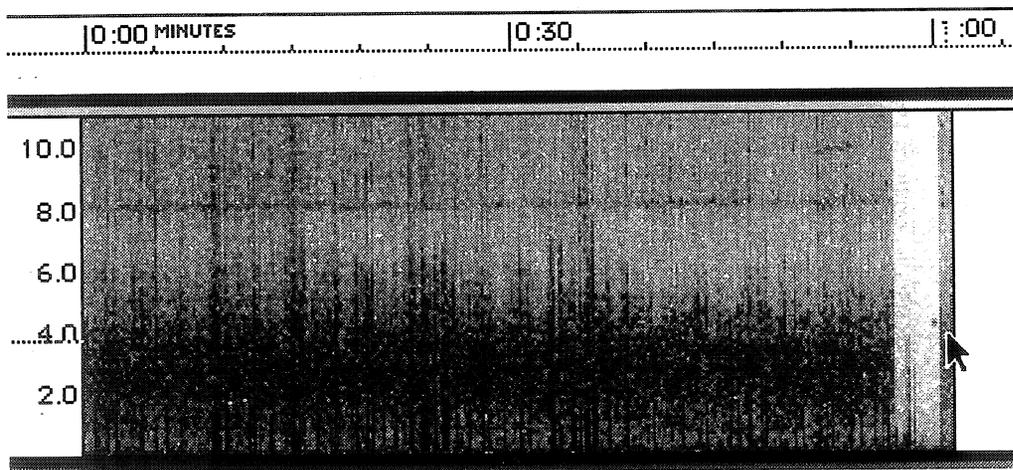


Signal from :03 - :05 seconds is momentary oscillation within the receiver.

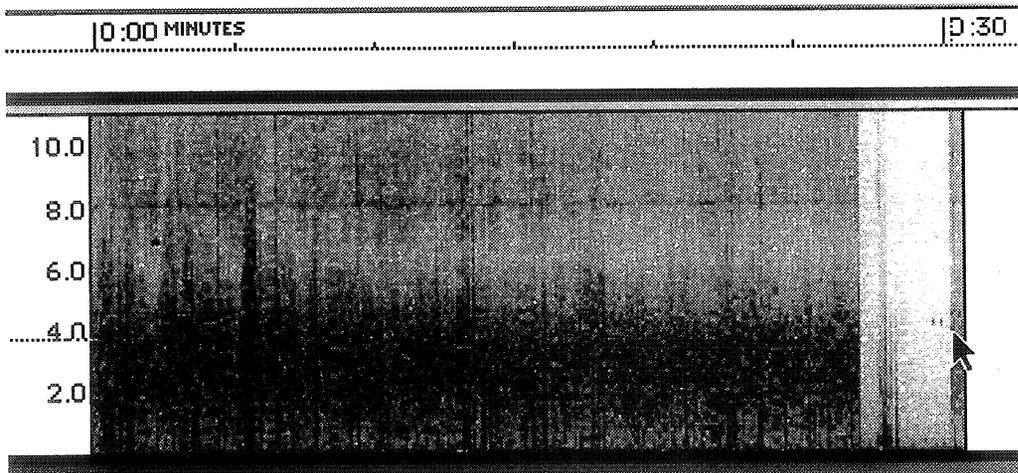
28-2



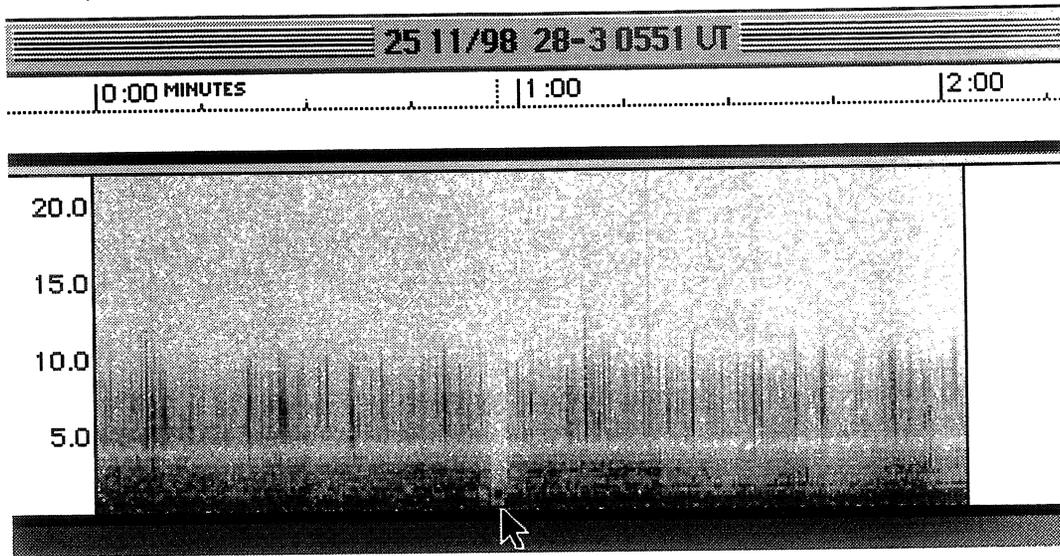
Team 5. Jean Claude Touzin, St. Vital, Quebec, CANADA. 0242 mark is in middle.



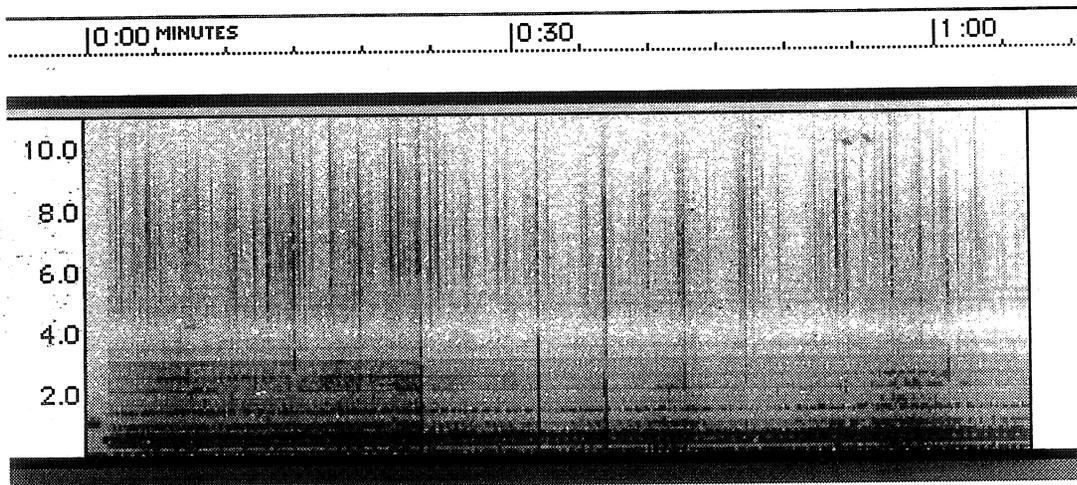
Arrow points to 0242 "beeps".



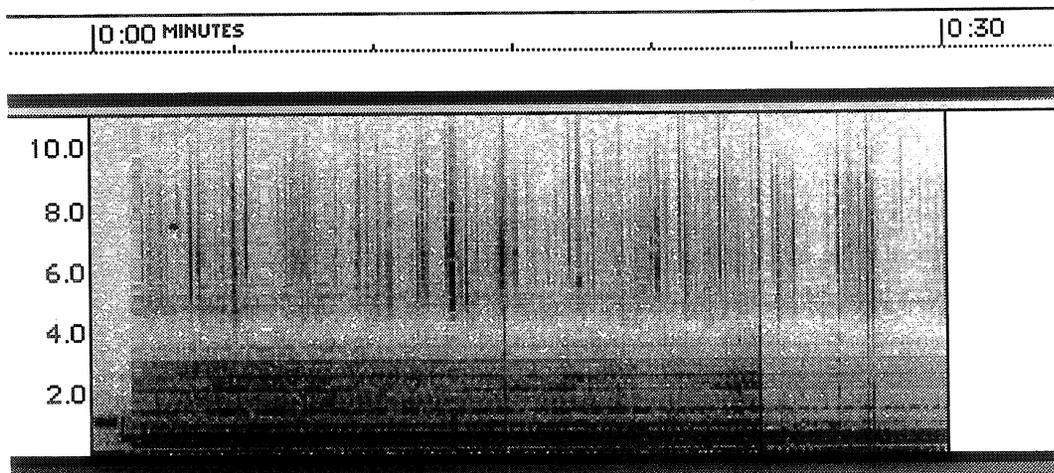
Thirty seconds leading up to time mark.



Team 25. Norm Anderson, Cedar Falls, Iowa. Arrow points to 0552 WWV tone.

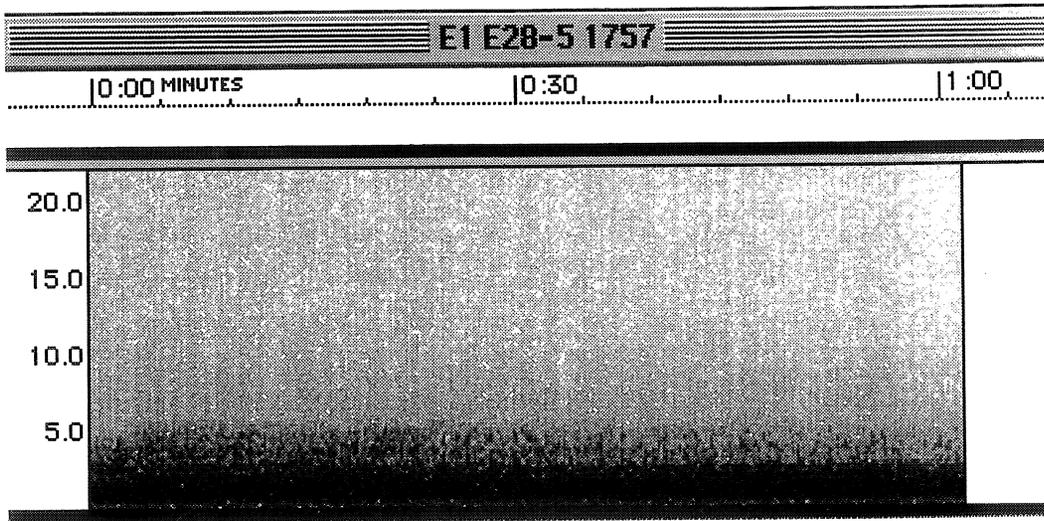


Last minute from above, starting with the WWV tone.

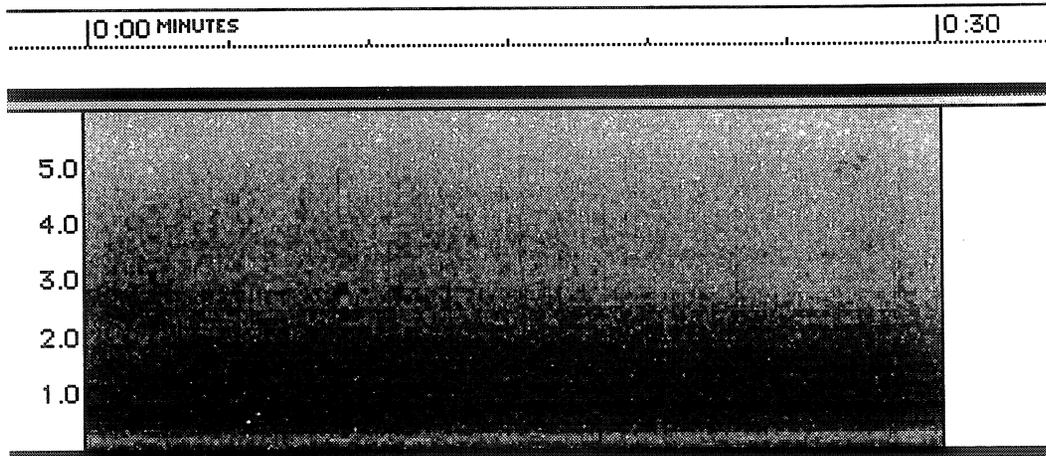


First 30 seconds of above.

E28-5

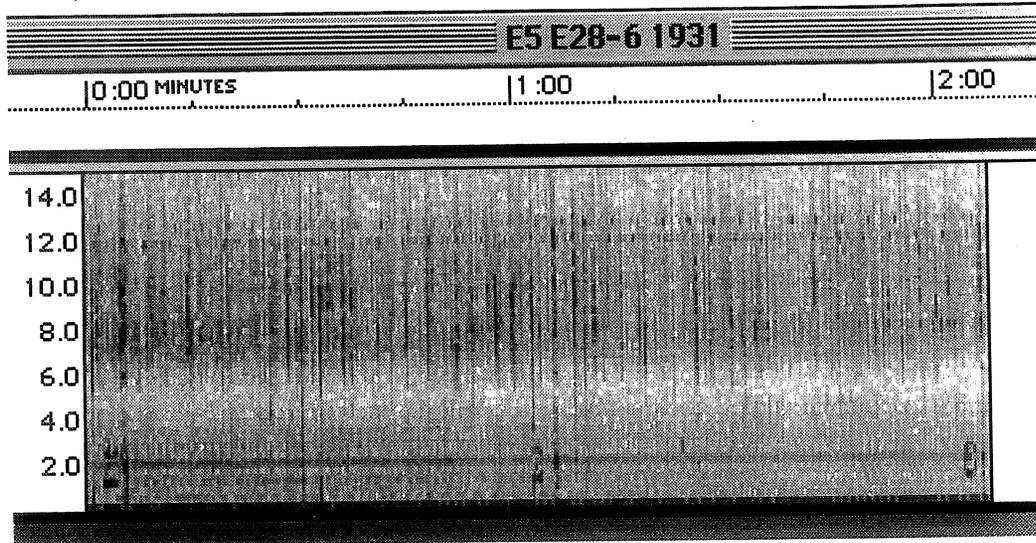


Team E1. Flavio Gori, Florence, ITALY.

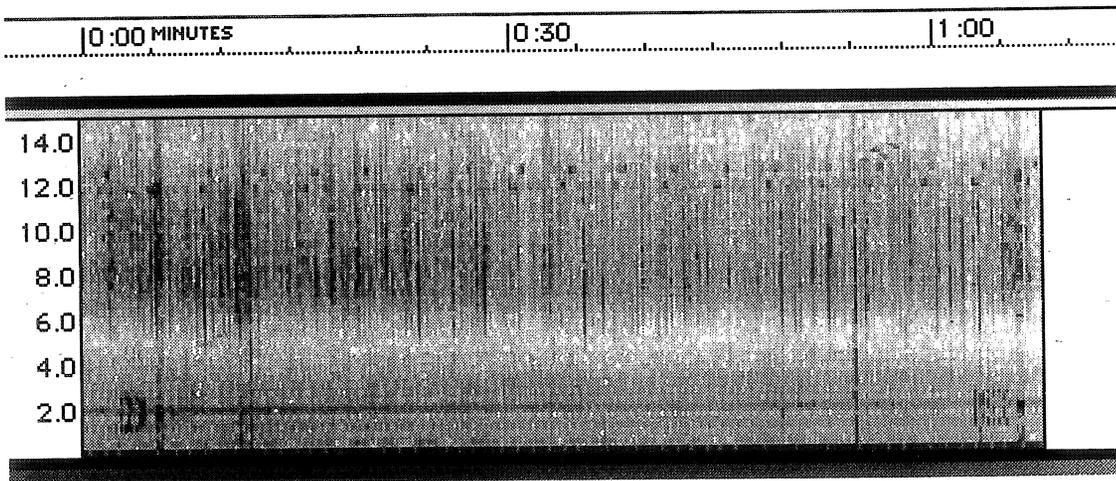


First 30 seconds of above using 0-6 kHz frequency range.

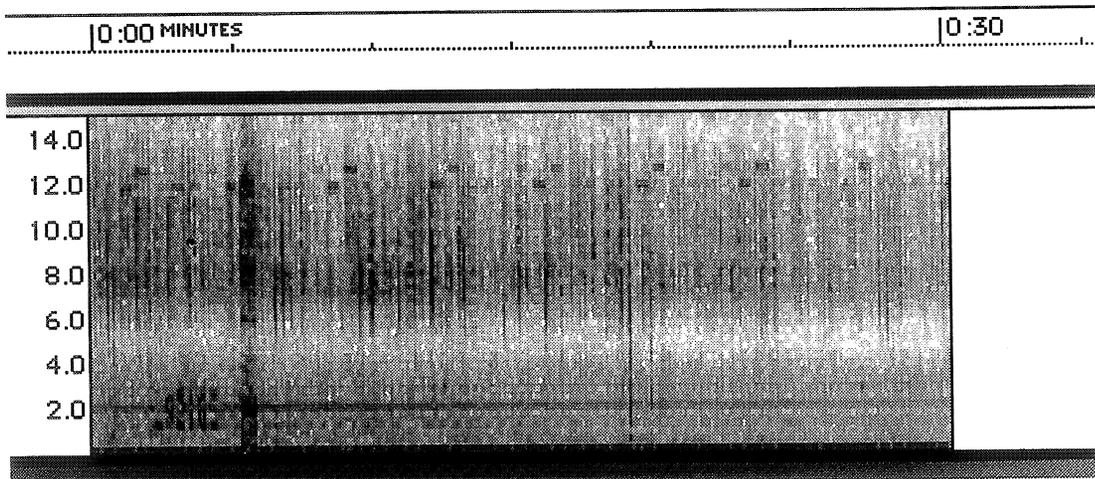
E28-6



Team E5. Renato Romero, Cumiana, ITALY. Time marks appear at 0, 1 and 2 minutes.

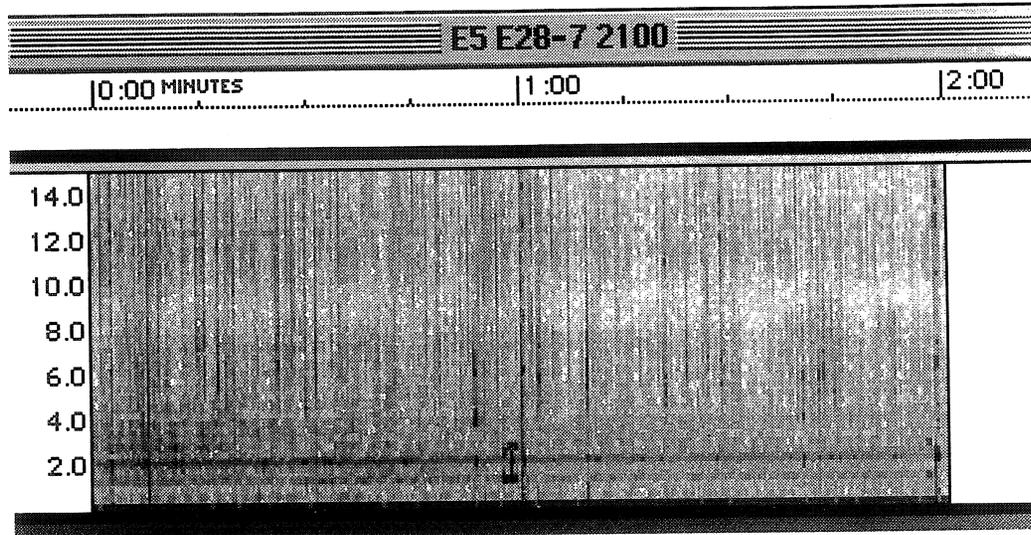


First minute. Strong Alpha signal.

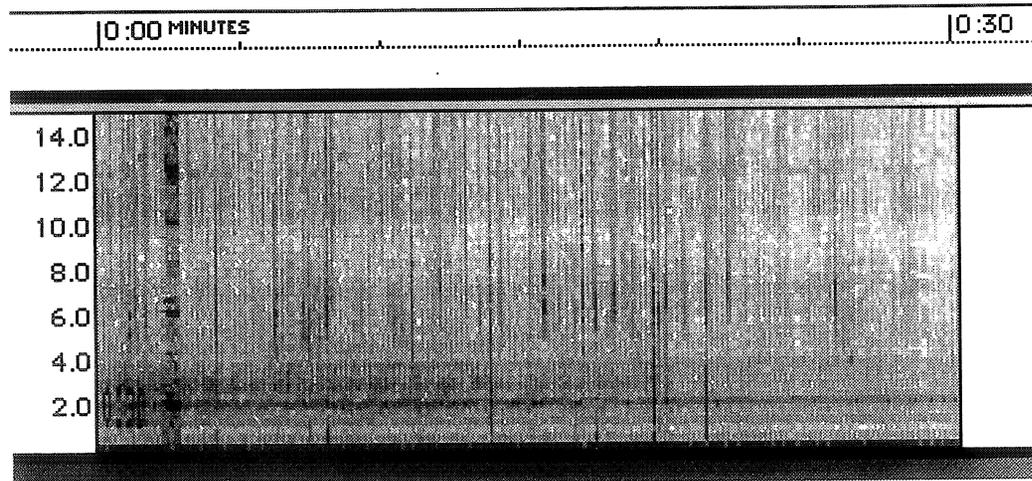
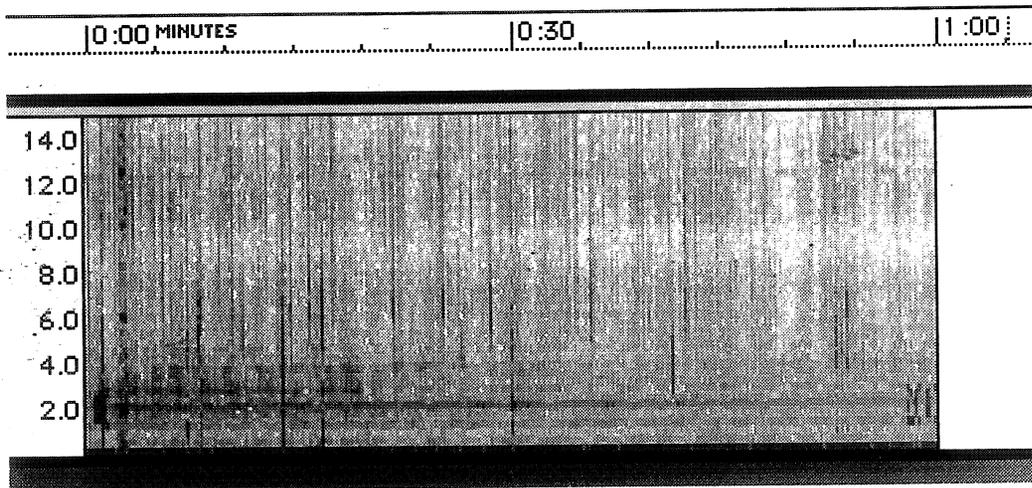


Time mark appears at the 5 second point.

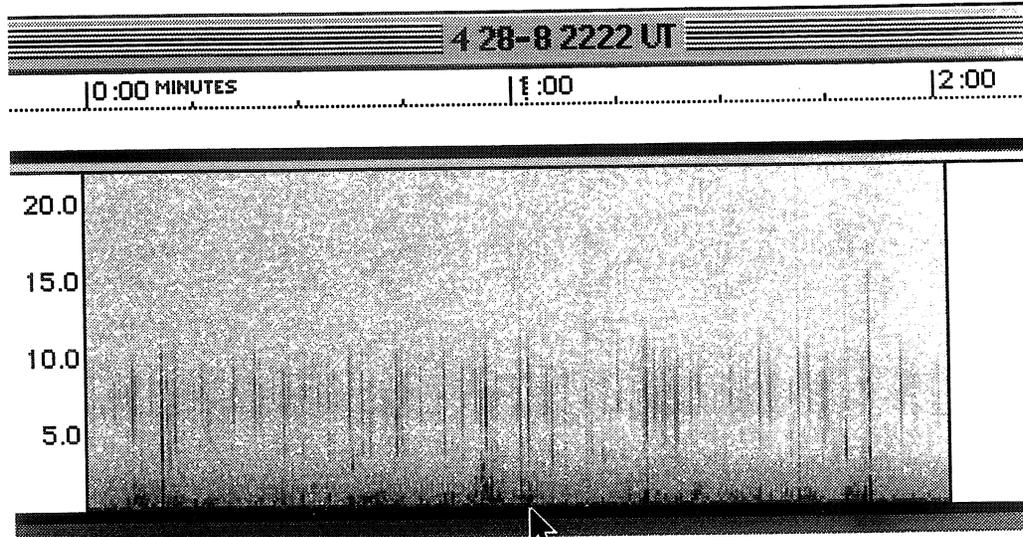
E28-7



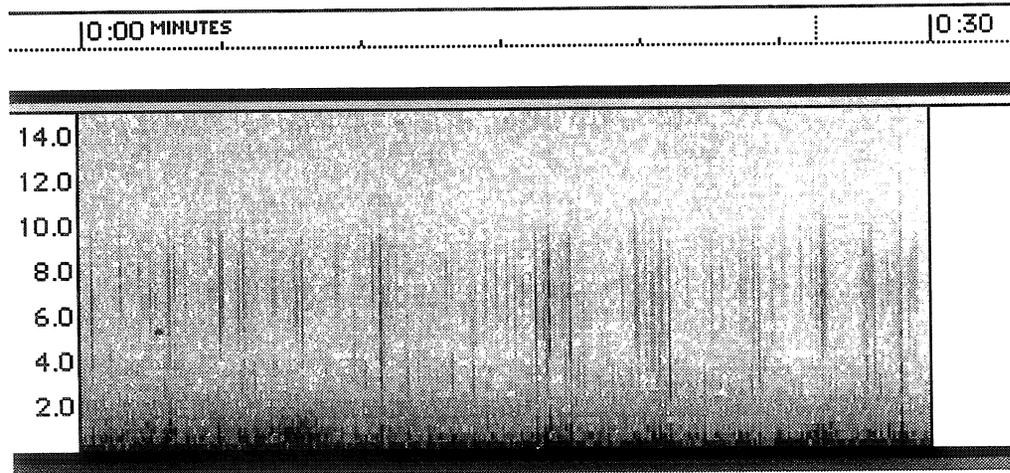
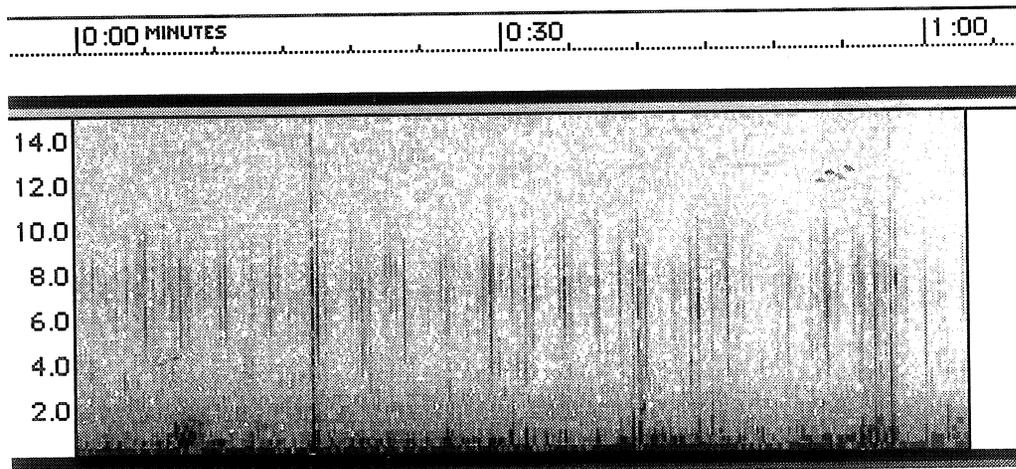
Team E5. Renato Romero, Cumiana, ITALY.



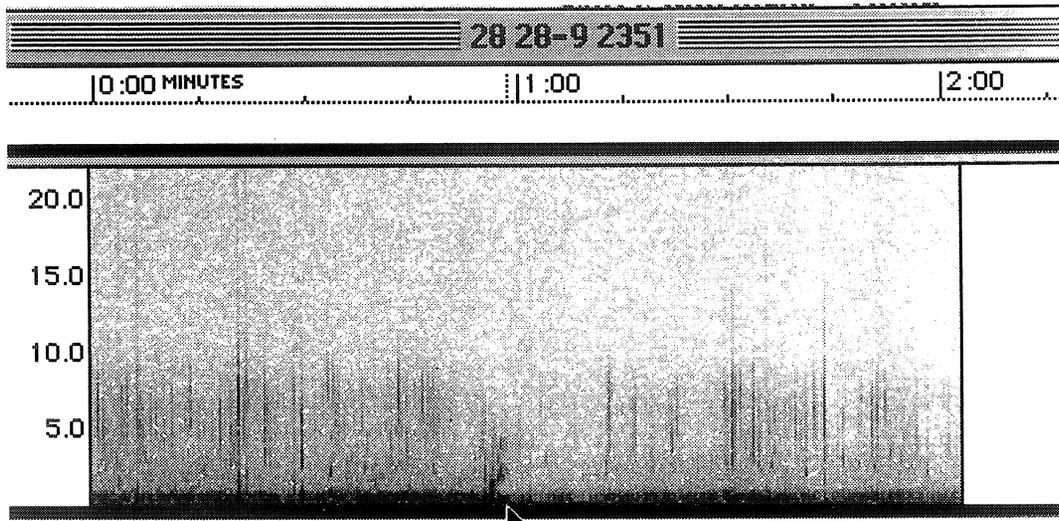
28-8



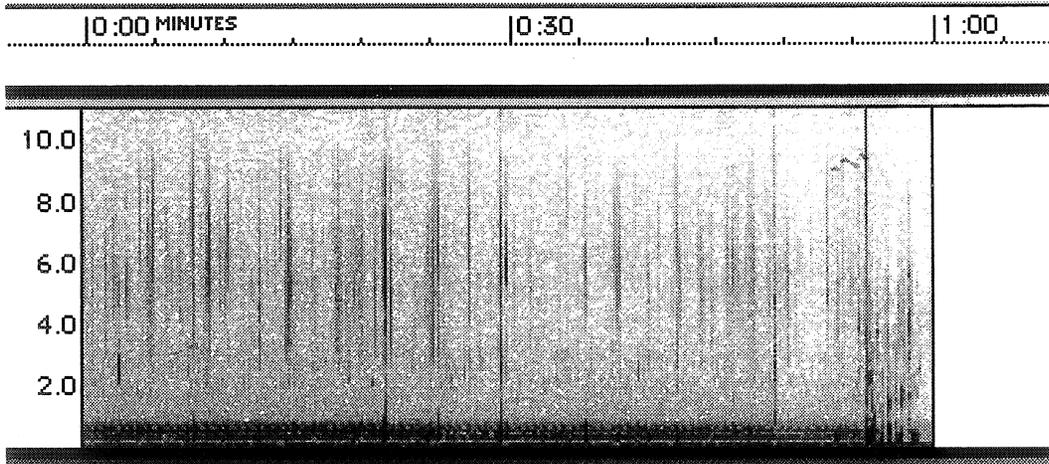
Team 4 Mike Aiello, Croton, New York. Arrow points to time mark at 22:23 UT.



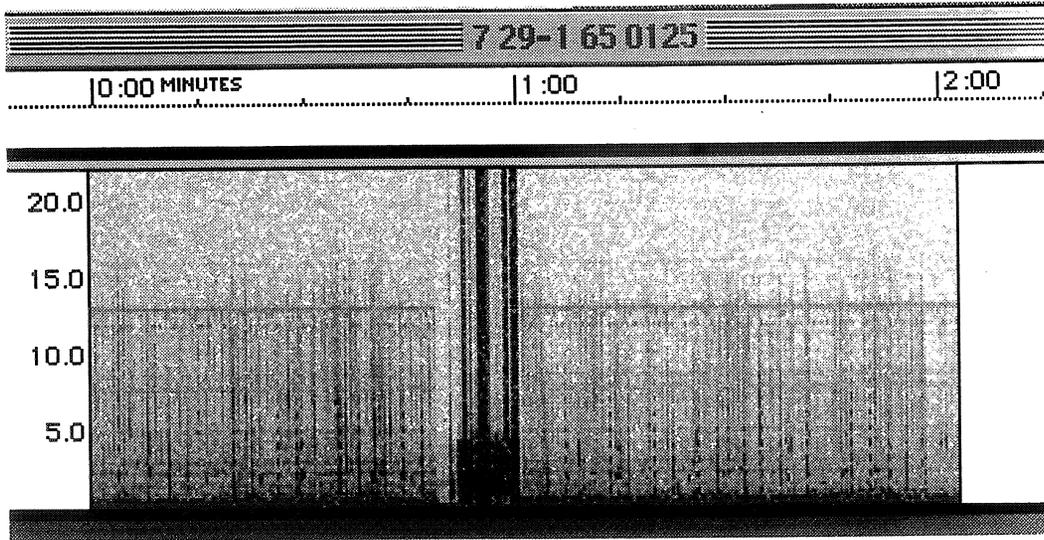
28-9



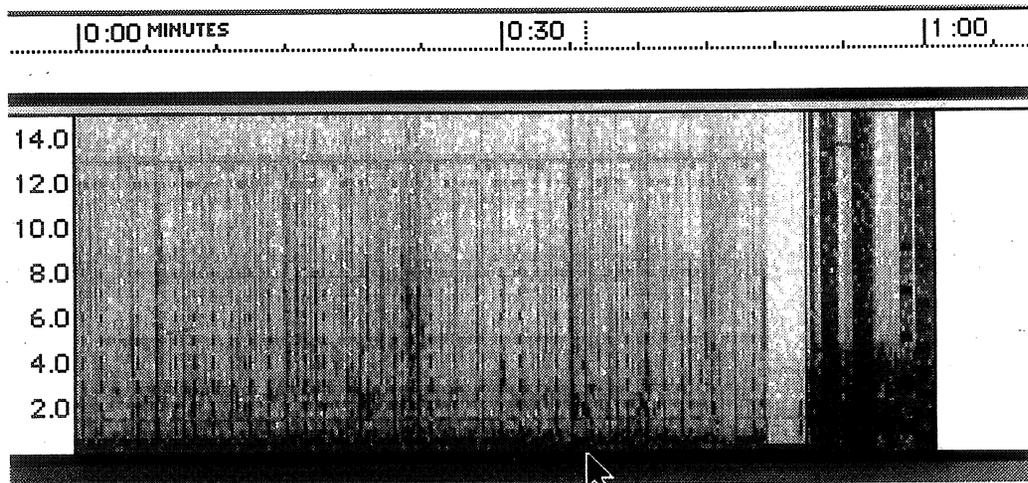
Team 28. Thomas Earnest, San Angelo, Texas. Arrow points to "mark" at 2352 UT.



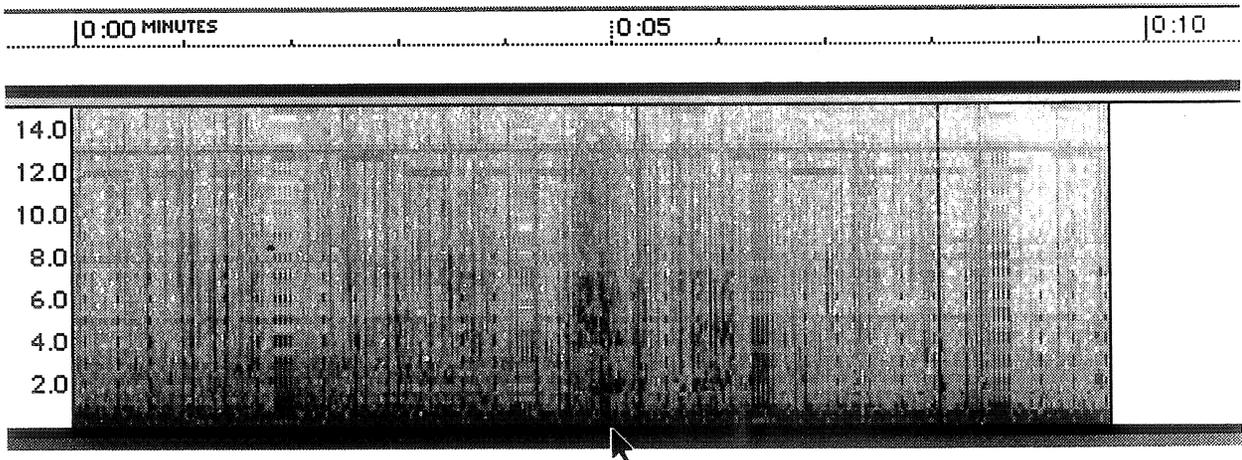
29-1



Team 7. Dean Knight, Sonoma Valley High School, Sonoma, California.

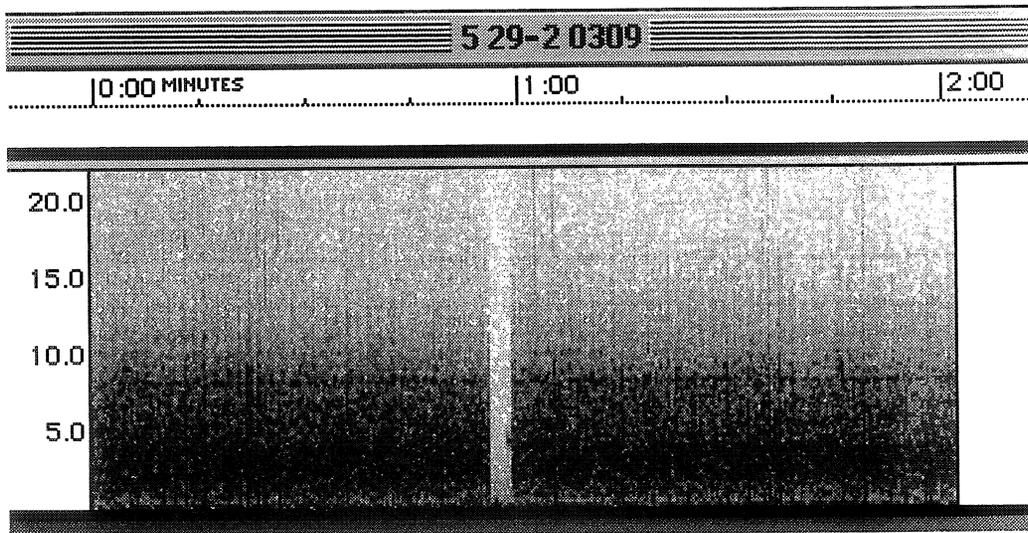


The first minute leading up to the WWV time mark. Arrow points to tweek burst.

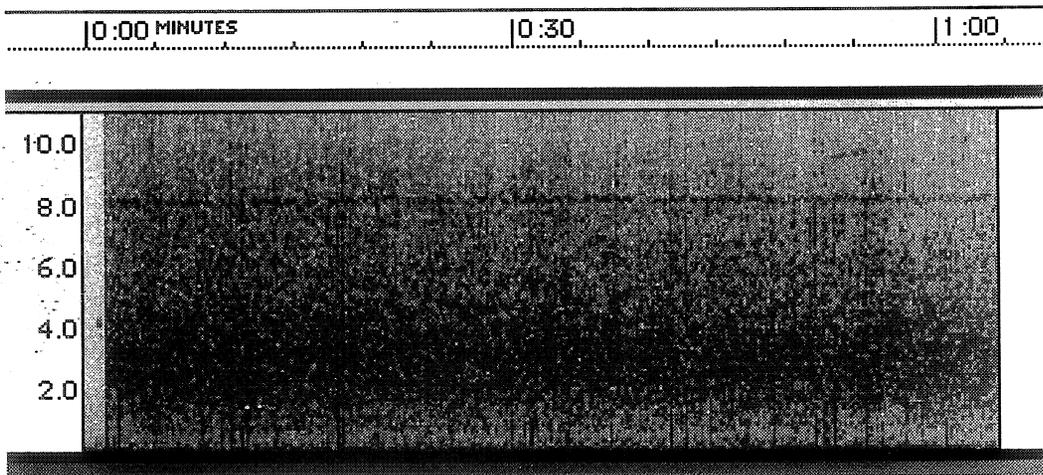


Closeup of tweek burst. Dashes at 12 kHz and above are faint Russian Alfa signals.

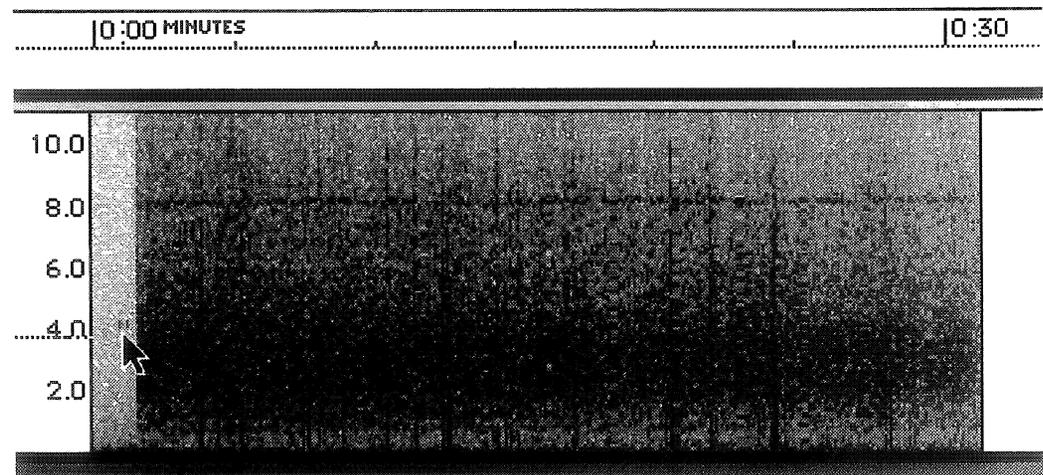
29-2



Team 5. Jean Claude Touzin, St. Vital, Quebec, CANADA. 0310 UT mark is at center.

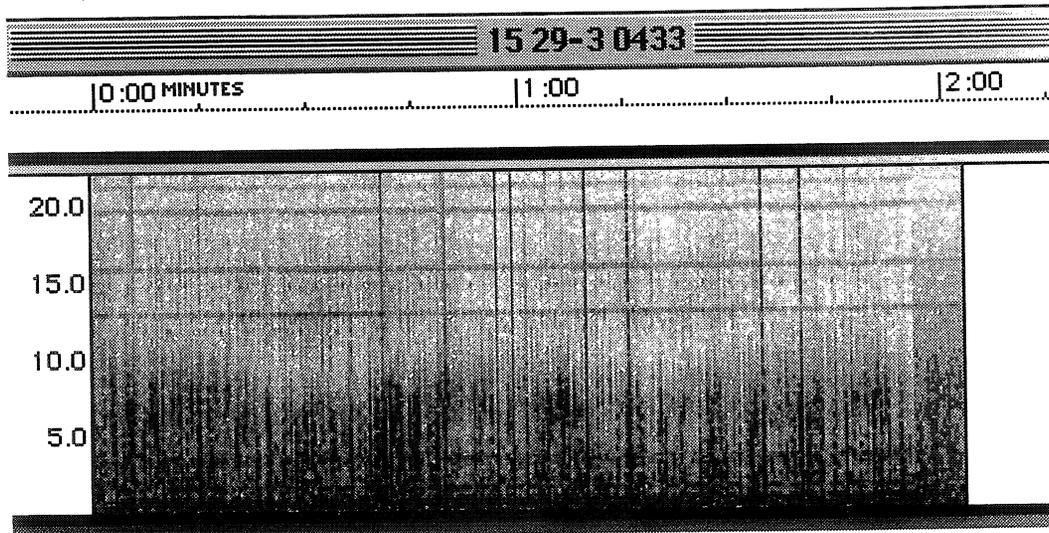


One minute starting at 0310 UT.

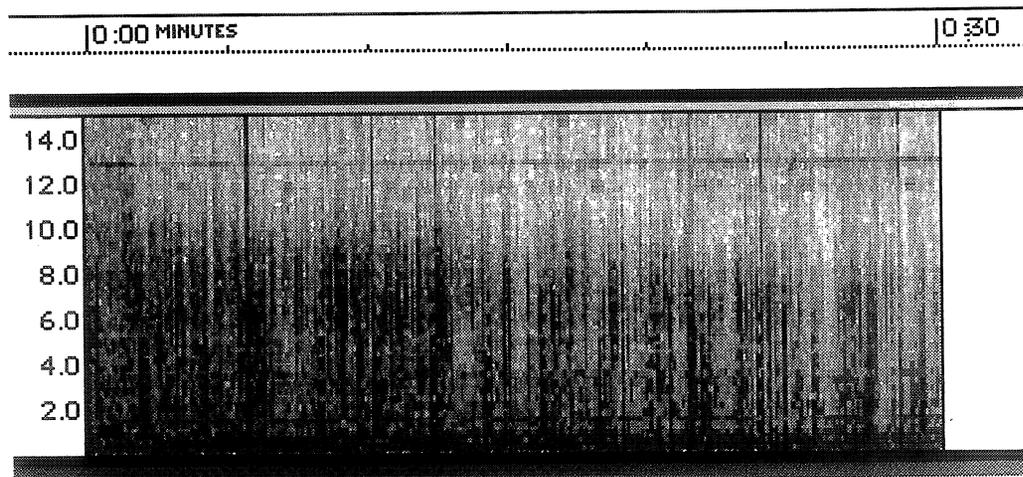
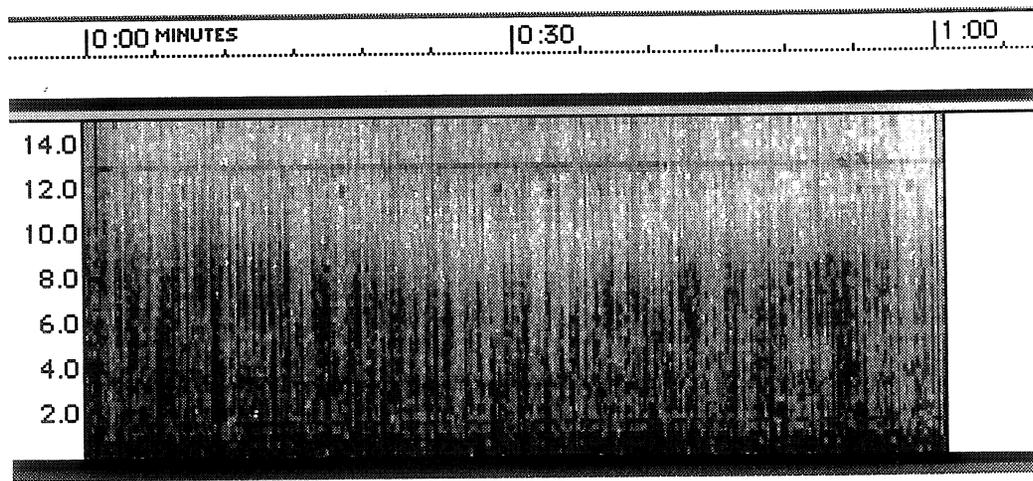


First 30 seconds of above.

29-3

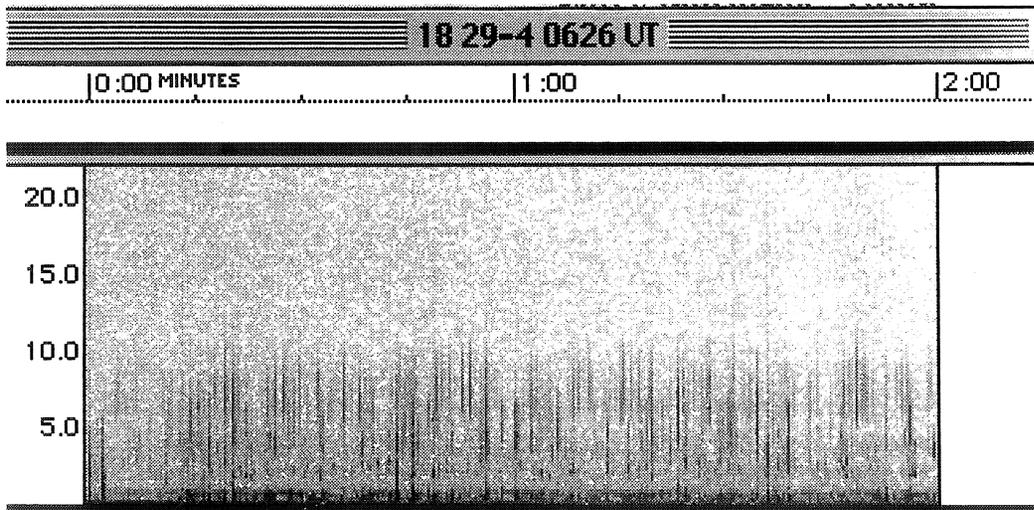


Team 15. Robert Bennett, Las Cruces, NM. Dense sferics, tweaks and LORAN.

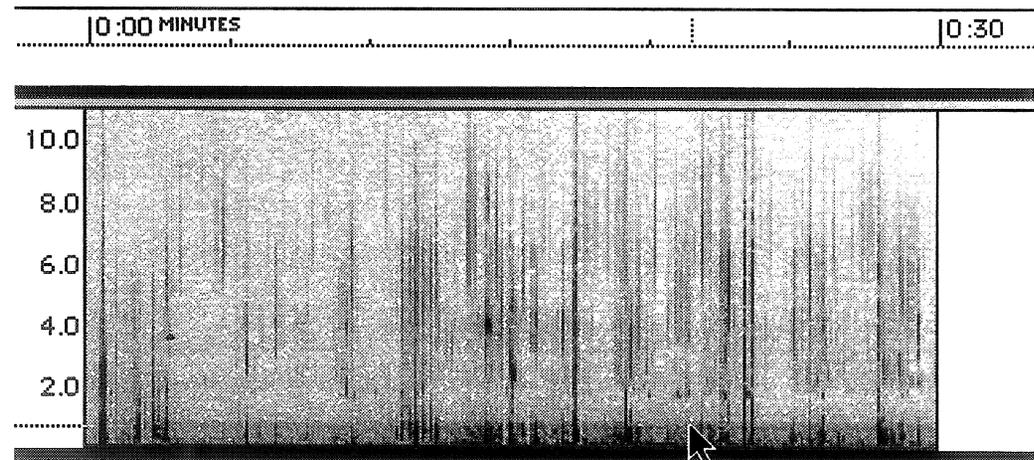
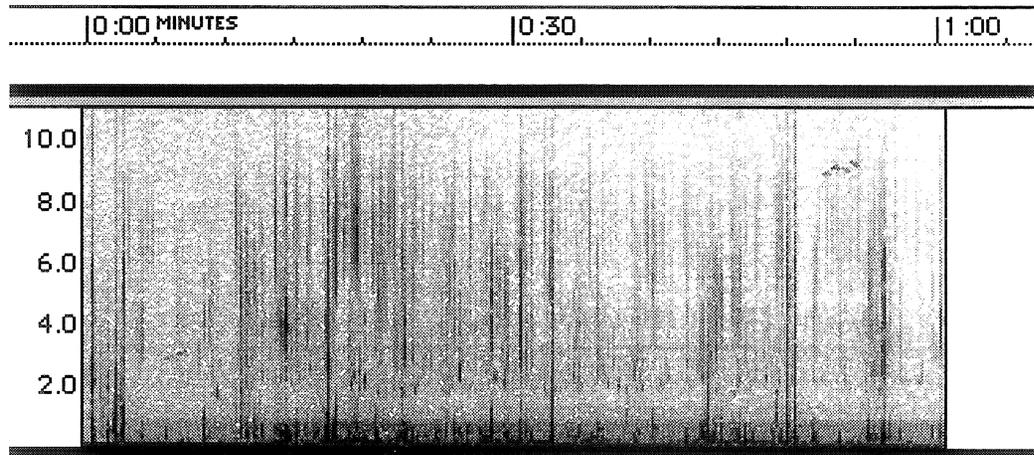


Dashes at about 12 kHz are Alpha navigation signals.

29-4



Team 18. David Jones, Columbus, Georgia.



The arrow points to a series of tweek bursts.

Report on Coordinated Observations 11/98

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 that time that would be whistlers, but other sounds such as tweeks, chorus, triggered emissions and even hiss are also interesting. Whistlers, however, remain 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. Unfortunately, Fall (November 28-29) did not provide many whistlers for observers. The following report includes sample spectrograms from contributing observers.

This table summarizes the sessions monitored by observers.

Date	11/28			11/29				
	1300	1400	1500	1200	1300	1400	1500	
Team								
1		C	C			C	C	
5				E	E	E		
21						C		
25		C			C			
29						C	C	
E5 *	07	08	09	10	07	08	09	10

The times indicated are UT times.

The letter in the box indicates the time zone of the observer:

E = EST = UT-4, C=CST = UT-5,

M = MST = UT-6 and P = PST = UT-7

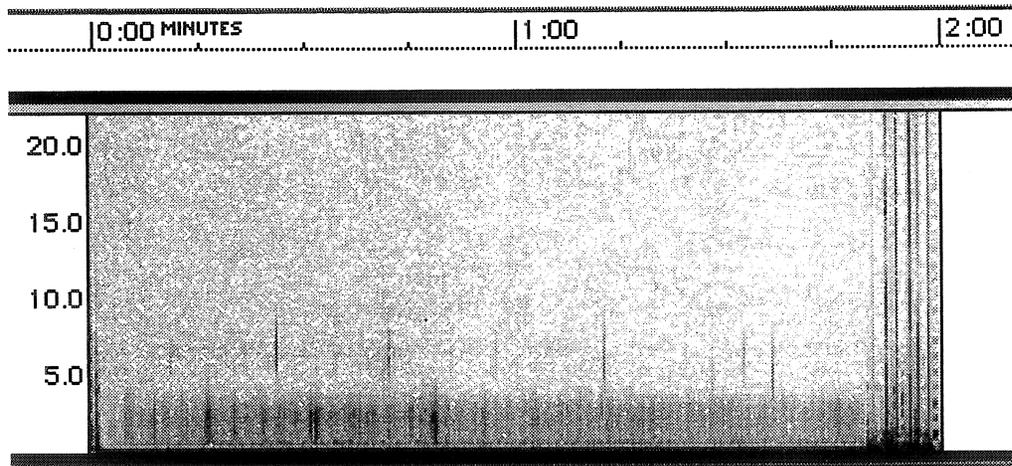
Team E5 observed in Italy where Local Time = UT + 1

Observers:	Team 1	Jack Lamb, Belton, Texas	(CST)
	Team 5	Jean-Claude Touzin, St. Vital, Quebec, CANADA	(EST)
	Team 21	Phil Hartzell, Aurora, Nebraska	(CST)
	Team 25	Norm Anderson, Cedar Falls, Iowa	(CST)
	Team 29	Janet Lowry, Houston, Texas	(CST)
	Team E5	Renato Romeru, Cumiana, ITALY	(UT+1)

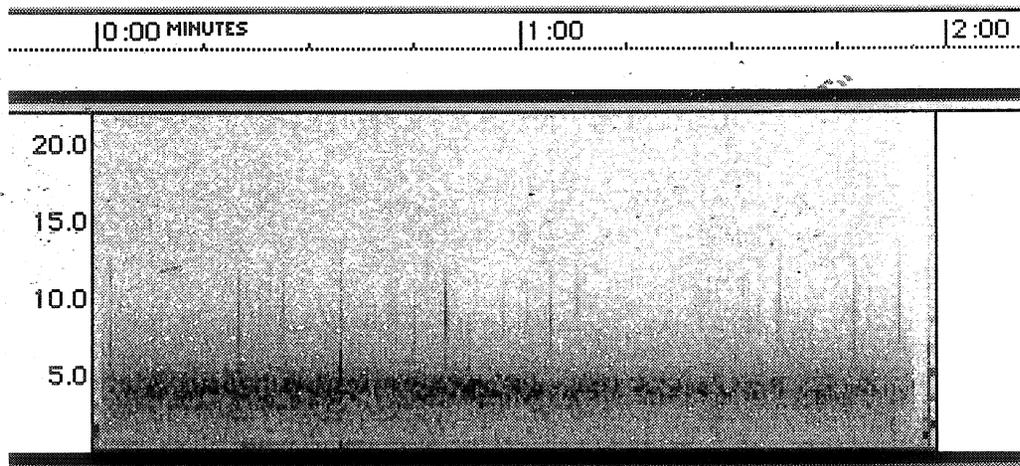
For analysis purposes, a spectrogram was made of the first two minutes of each 12-minute hourly session. Additional spectrograms were made of any items of interest and of any segments requested by the observer. Time marks were placed on the tape every two minutes and a complete log was made of each session.

11/28/98 1400 UT

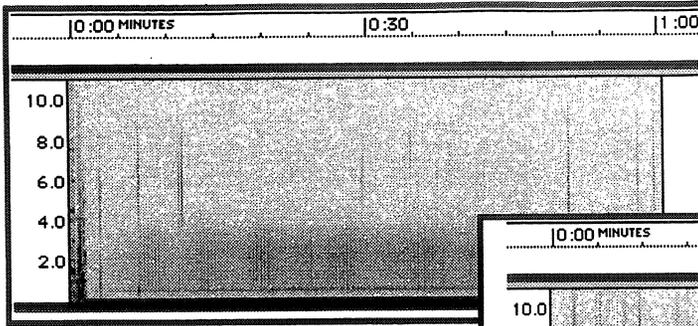
Observations were started off by Jack Lamb in Texas and Norm Anderson in Iowa.



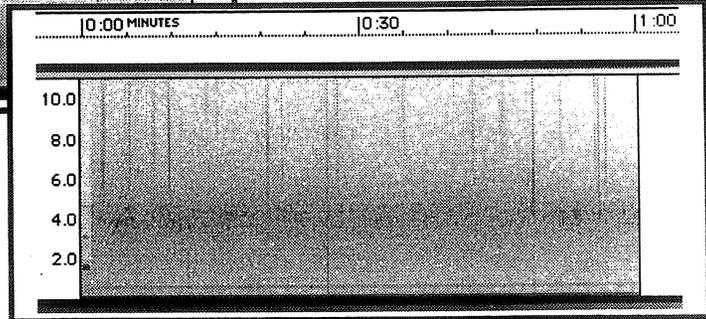
Jack Lamb in Belton, TX, had quiet conditions with very little manmade hum.



Norm Anderson in Cedar Falls, IA, had very similar quiet conditions.



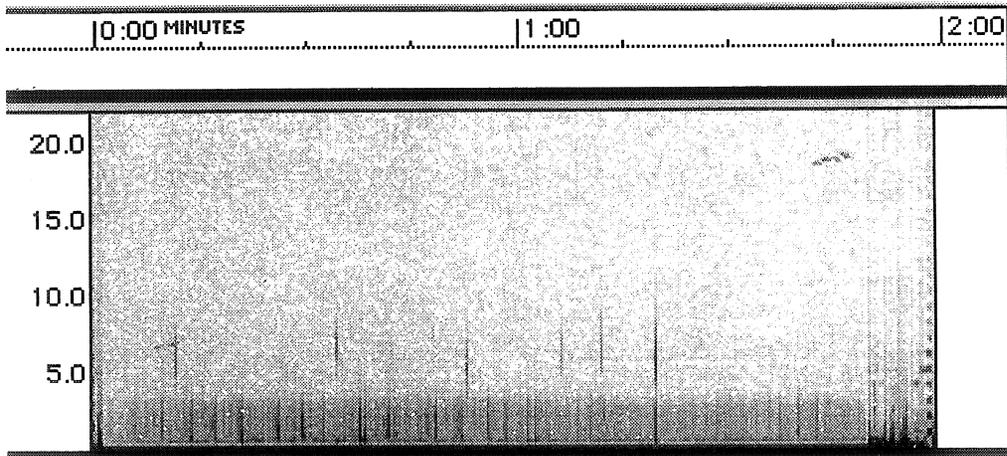
Team 1



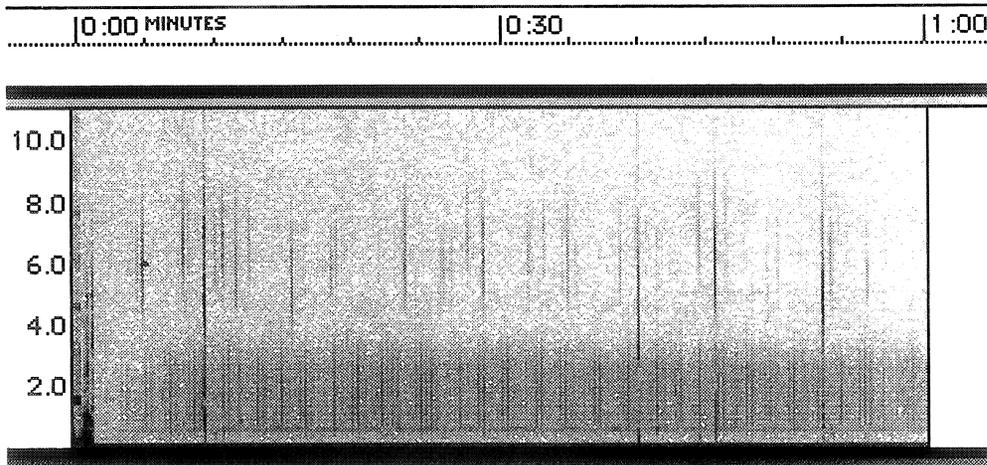
Team 25

First minute at 1400 UT.

11/28/98 1500 UT

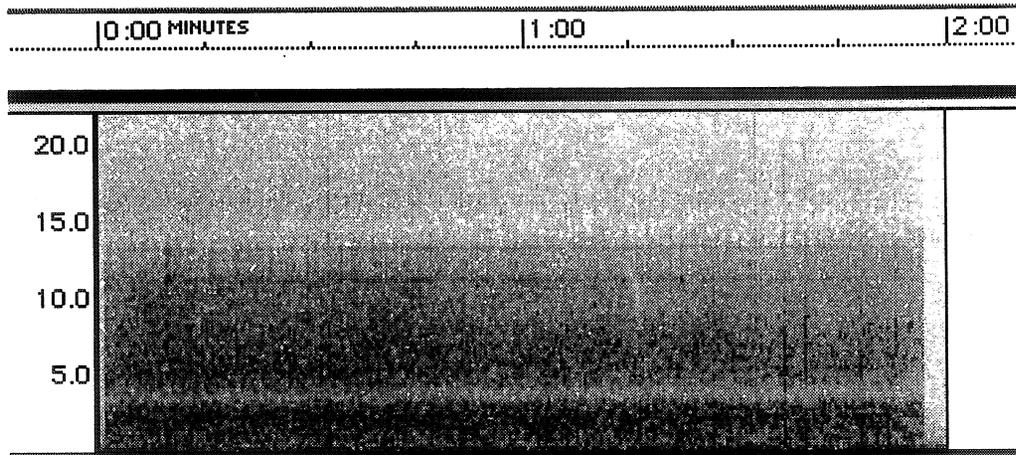


Team 1, Jack Lamb of Belton, TX, at 0900 CST, 1500 UT. Quiet conditions prevail.

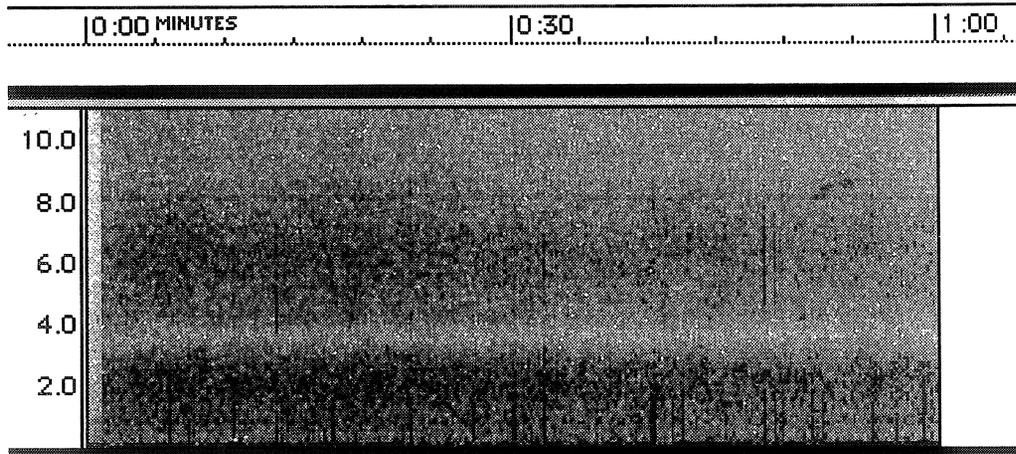


The first minute at 1500 UT. Starts with WWV tone.

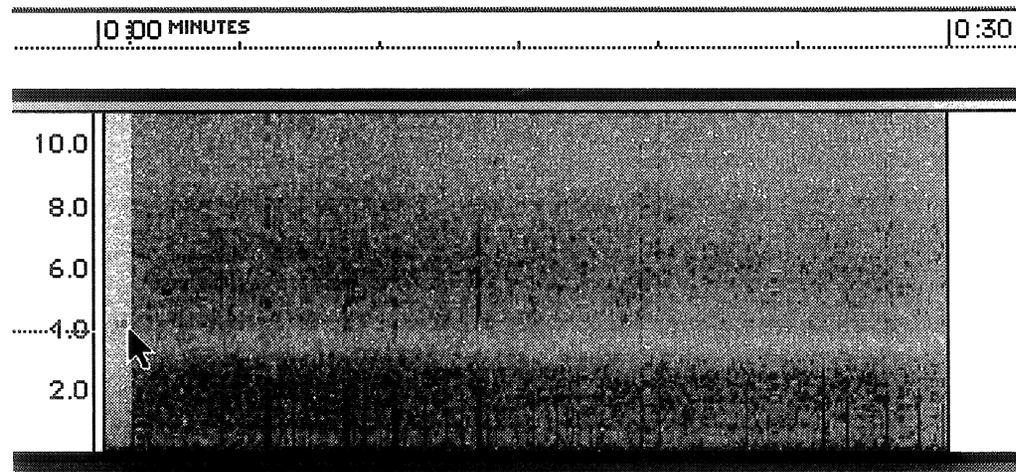
11/29/98 1200 UT



Team 5 Jean Claude Touzin, St. Vital, Quebec, CANADA

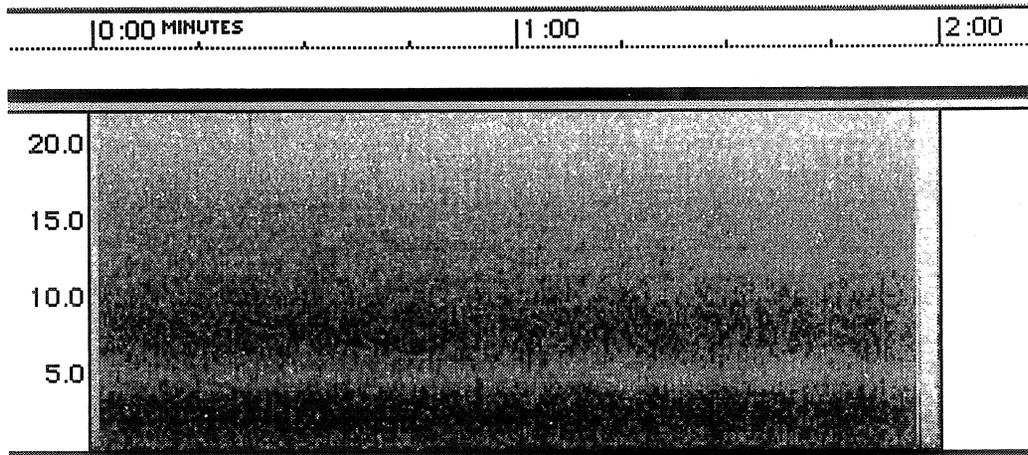


First minute. Quiet conditions.

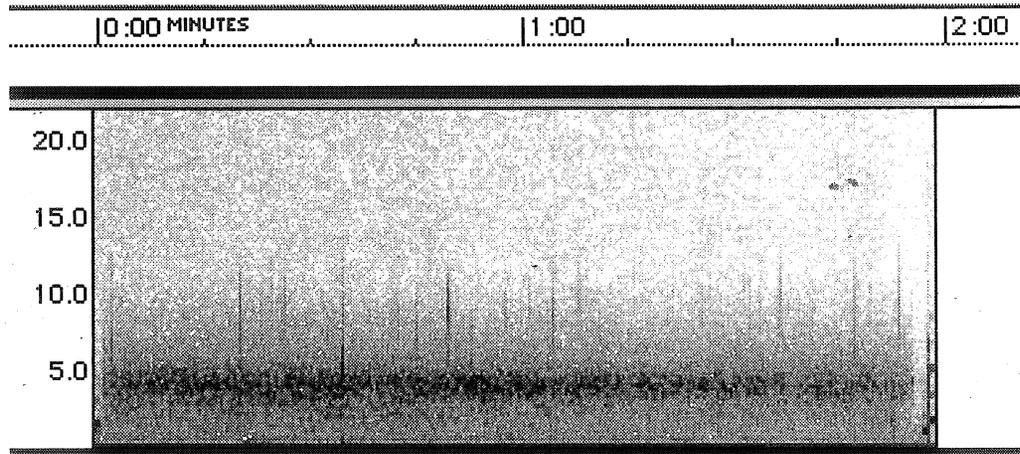


First 30 seconds. Arrow points to "beeps" at 7:00 AM EST

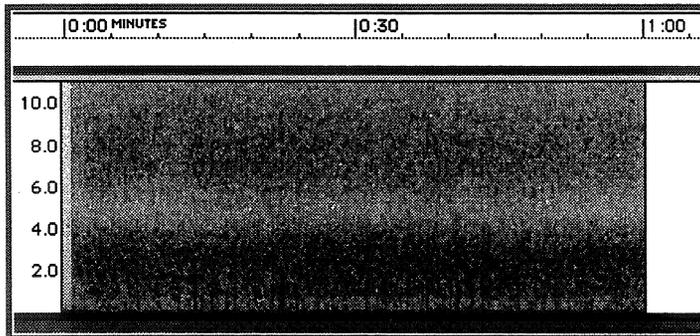
11/29/98 1300 UT



Team 5 Jean Claude Touzin, St. Vital, Quebec, CANADA

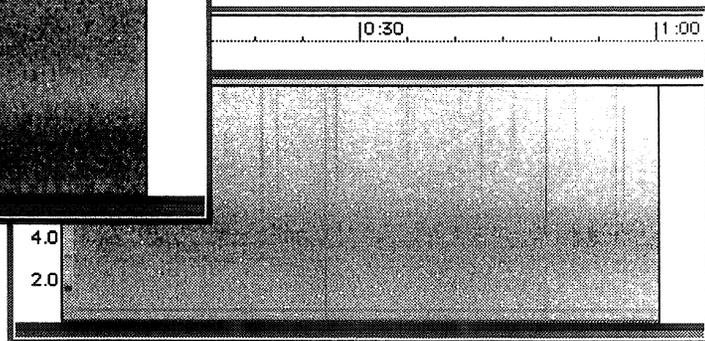


Team 25 Norm Anderson, Cedar Falls, Iowa



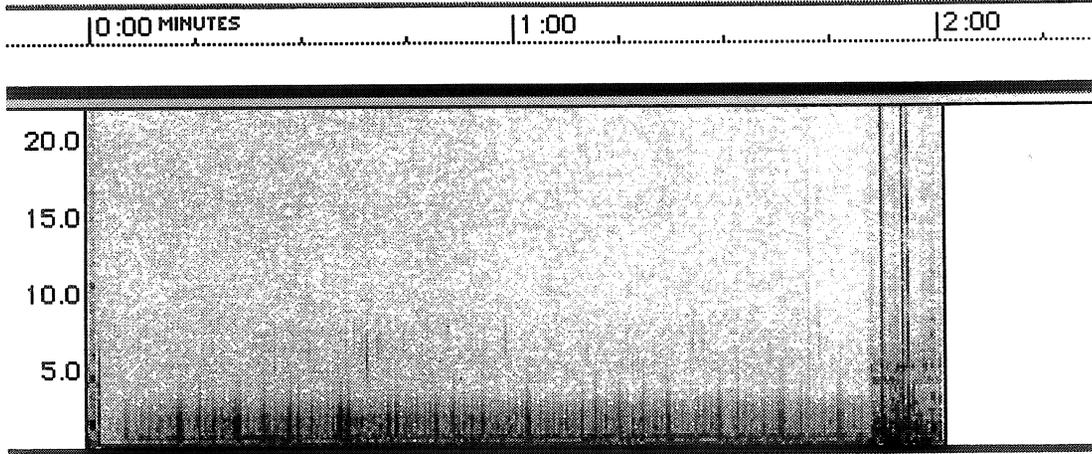
Team 5

Team 25

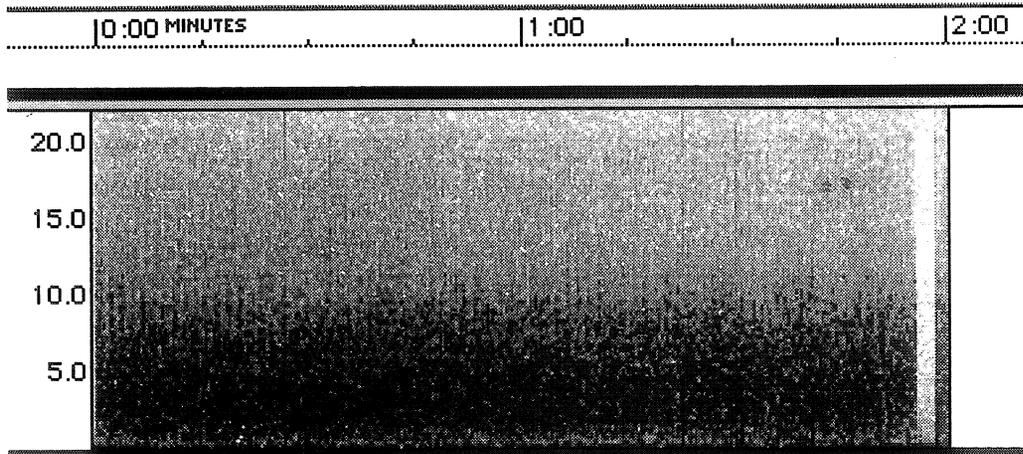


First minute.

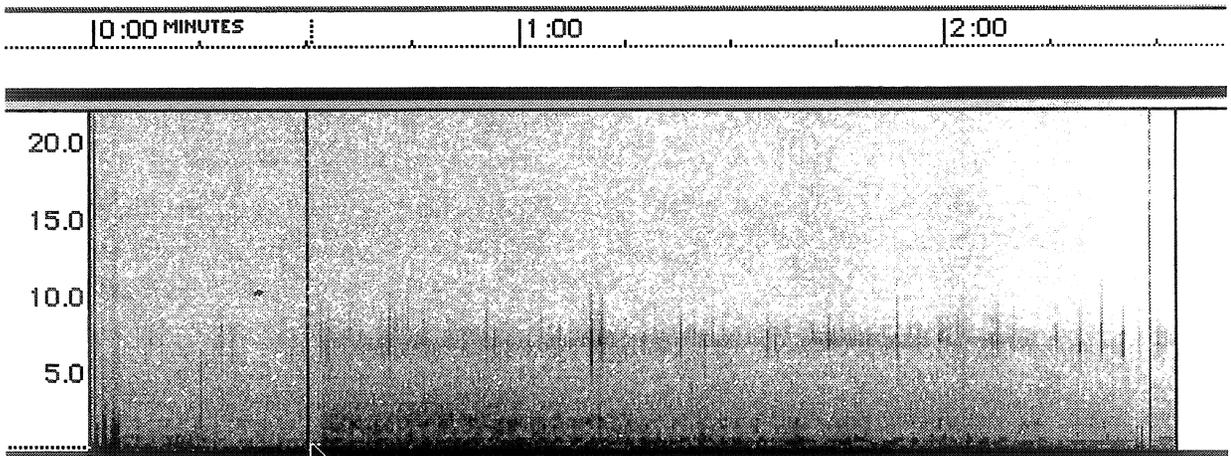
11/19/98 1400 UT



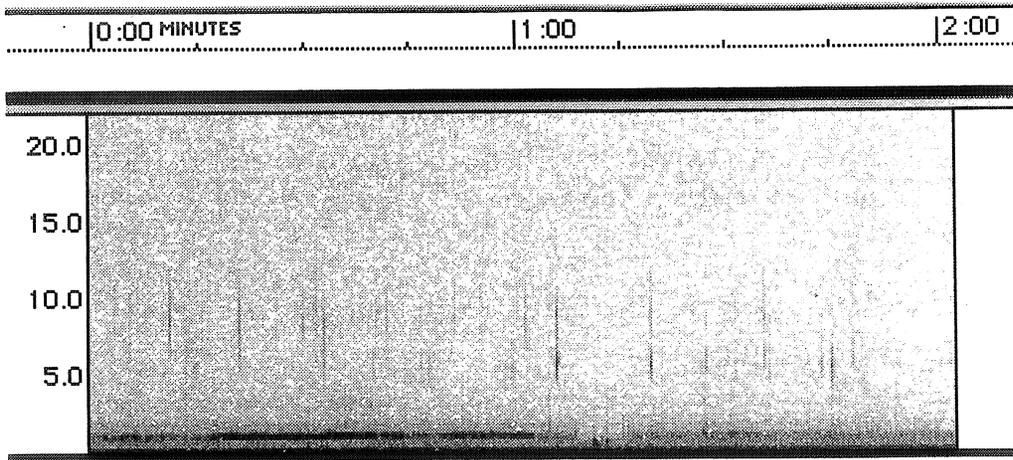
Team 1 Jack Lamb, Belton, Texas



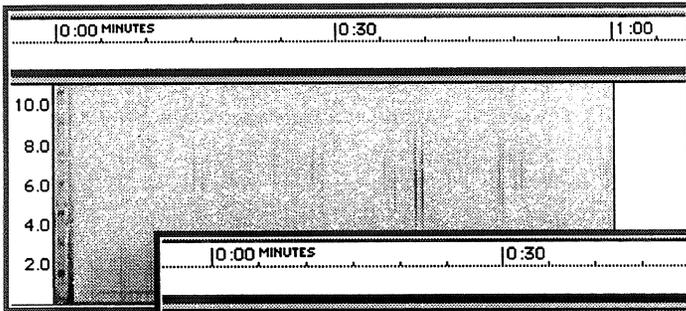
Team 5 Jean Claude Touzin, St. Vital, Quebec, CANADA



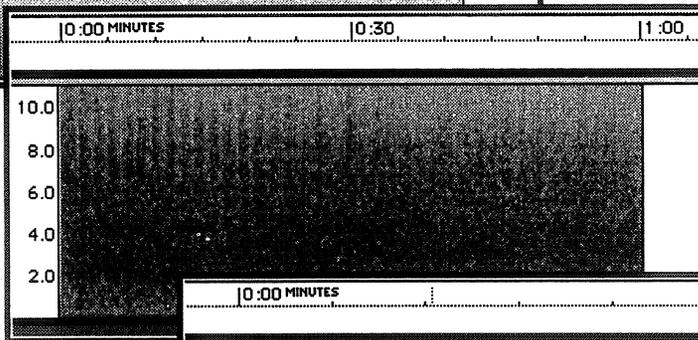
Team 21. Phil Hartzell, Aurora, Nebraska



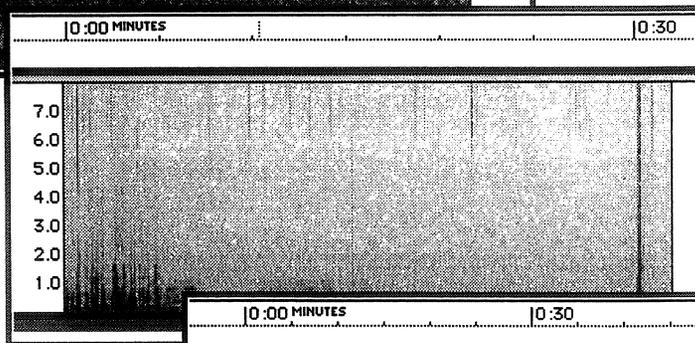
Team 29 Janet Lowry, Houston, Texas



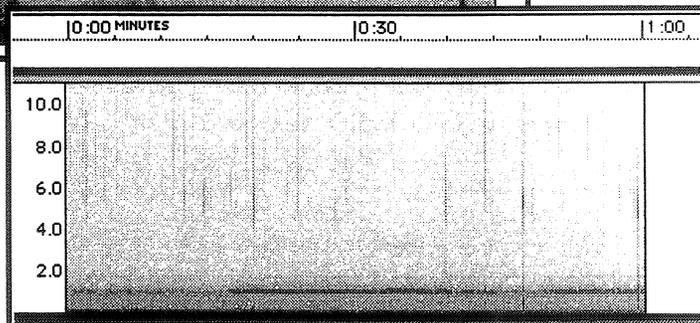
Team 1



Team 5

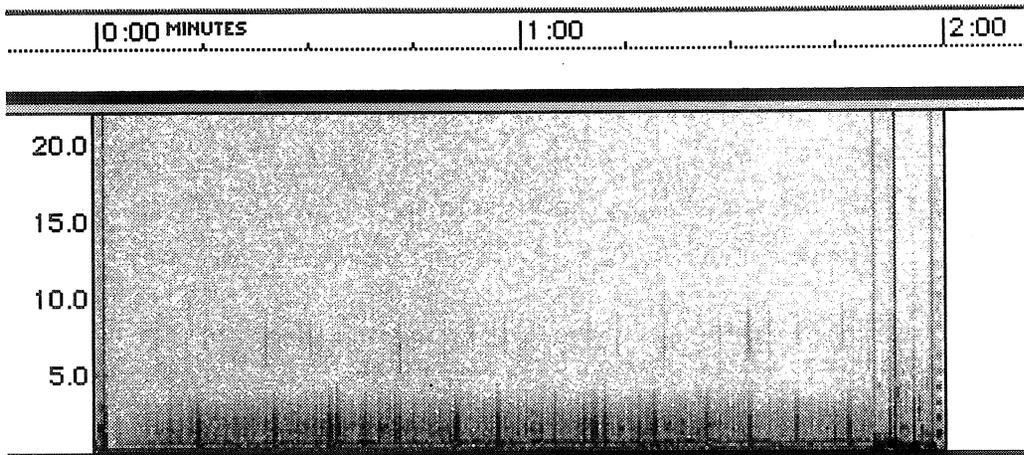


Team 21

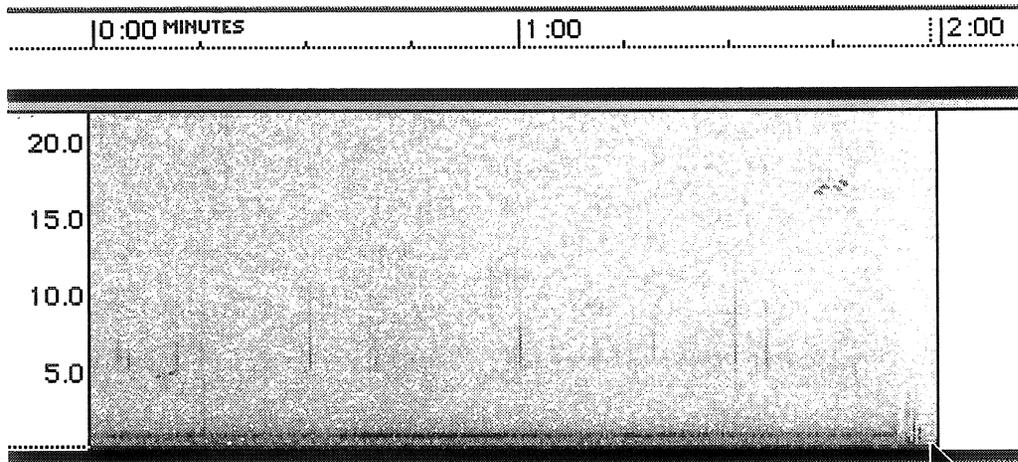


Team 29

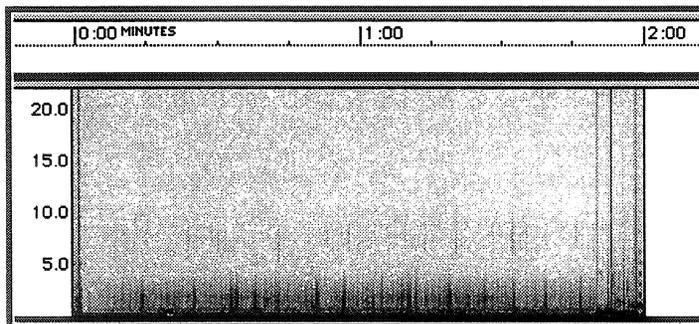
11/29/98 1500 UT



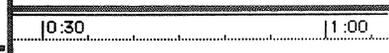
Team 1 Jack Lamb, Belton, Texas



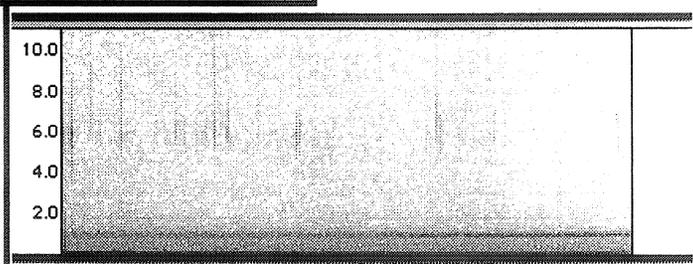
Team 29 Janet Lowry, Houston, Texas



Team 1



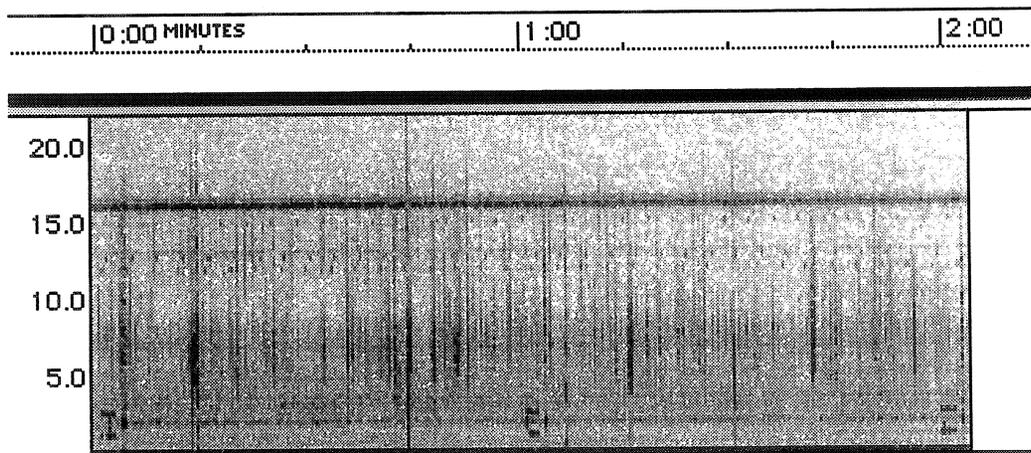
Team 29



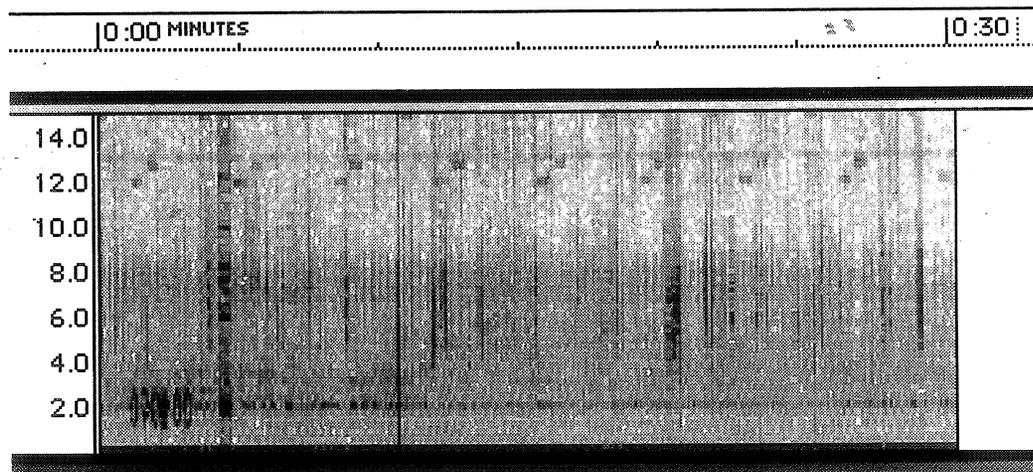
European Coordinated Observations

Team E5 Renato Romero, Cumiana, ITALY, made a complete set of observations hourly from 0700 - 1000 local time on both 11/28 and 11/29. At his location, local time = UT + 1 hour.

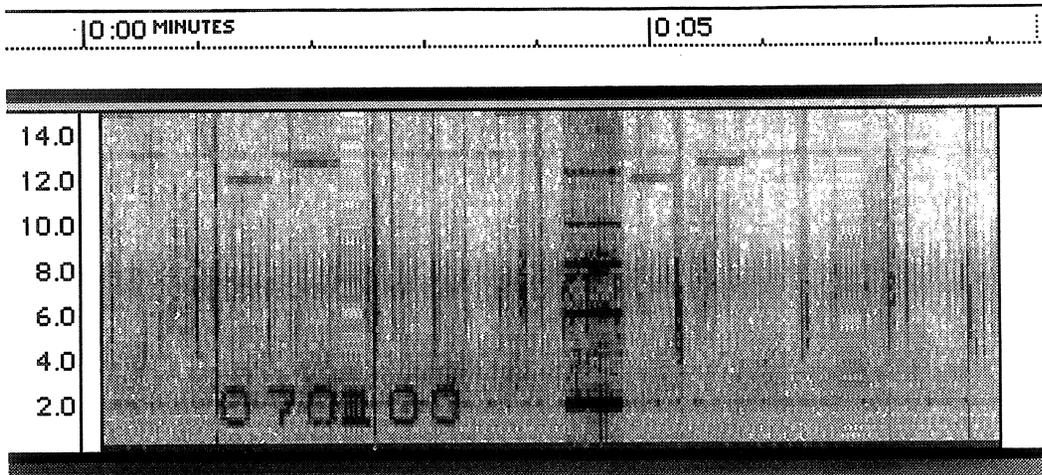
11/28



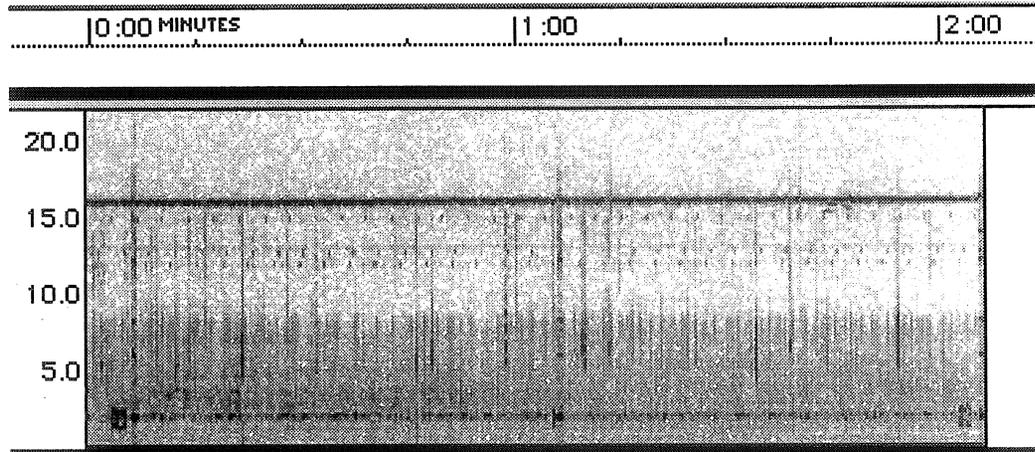
0801 AM Local, 0701 UT



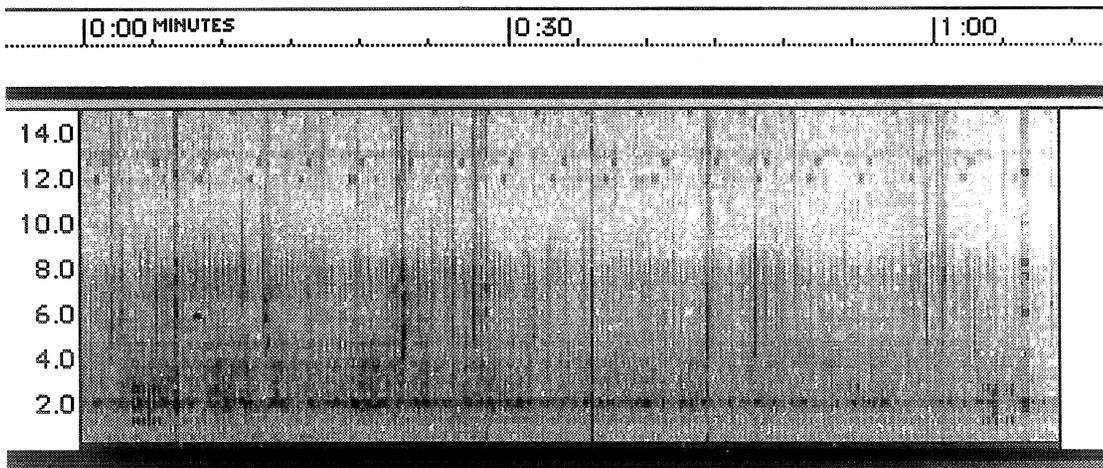
First 30 seconds. 0-15 kHz range to show Alpha signals.
At the very beginning of the file is the time mark inserted automatically using a laptop computer and the ATM software from Mike Aiello.



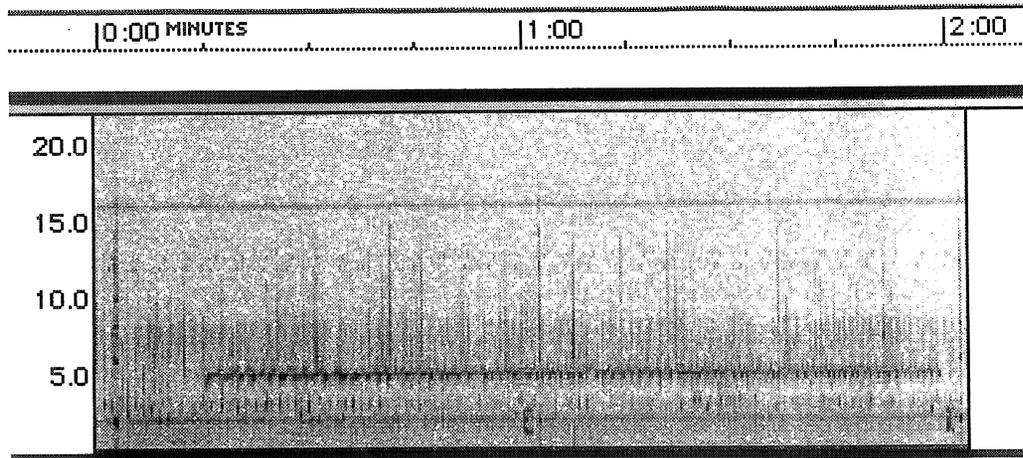
A closeup of the time mark and time tone at 2 kHz plus some harmonics.
The dashes between 12 and 14 kHz are Alpha signals.



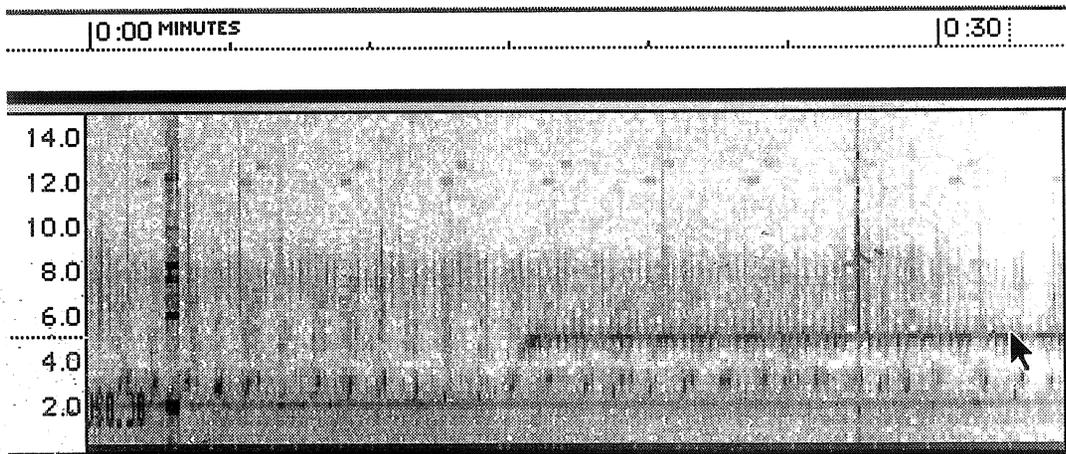
0901 AM Local; 0800 UT



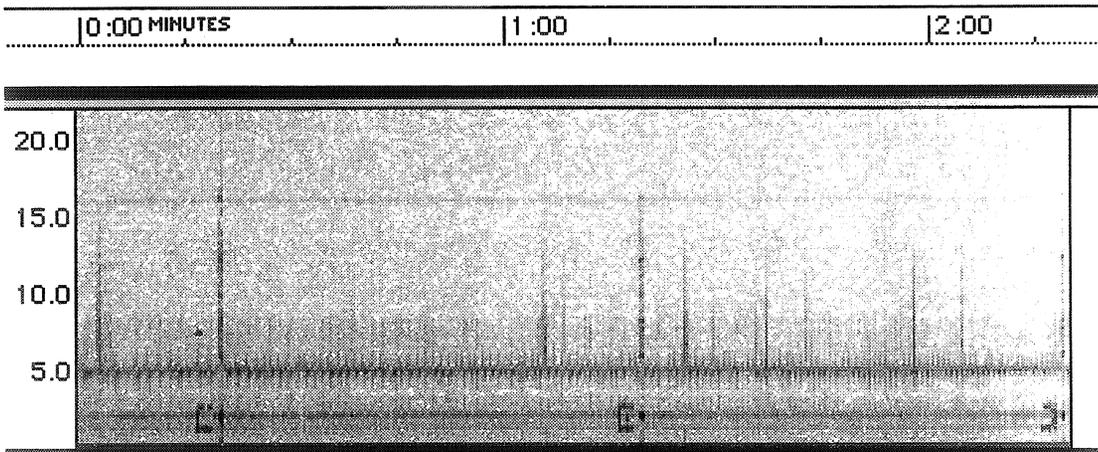
First minute.



10:00 AM Local; 0900 UT



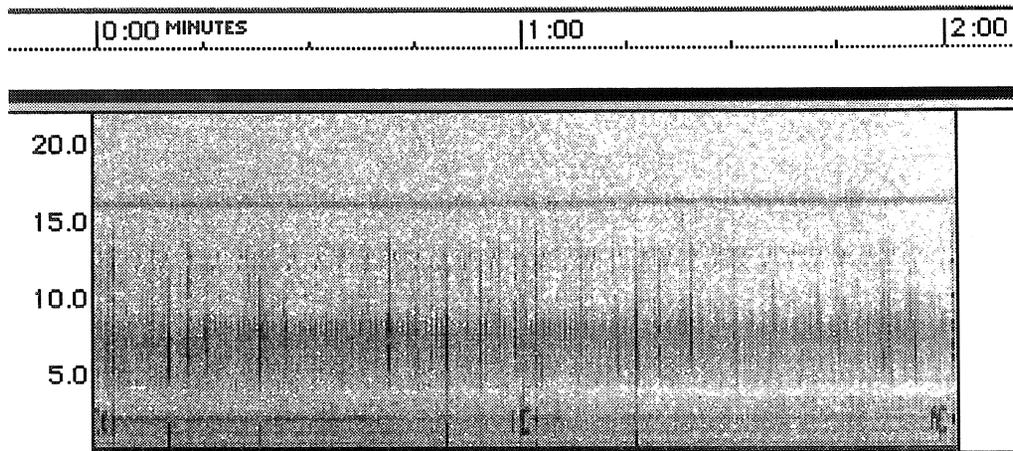
First 30 seconds. Arrow points to a whirring signal resembling a car ignition system that started 15 seconds into the file and persisted throughout.



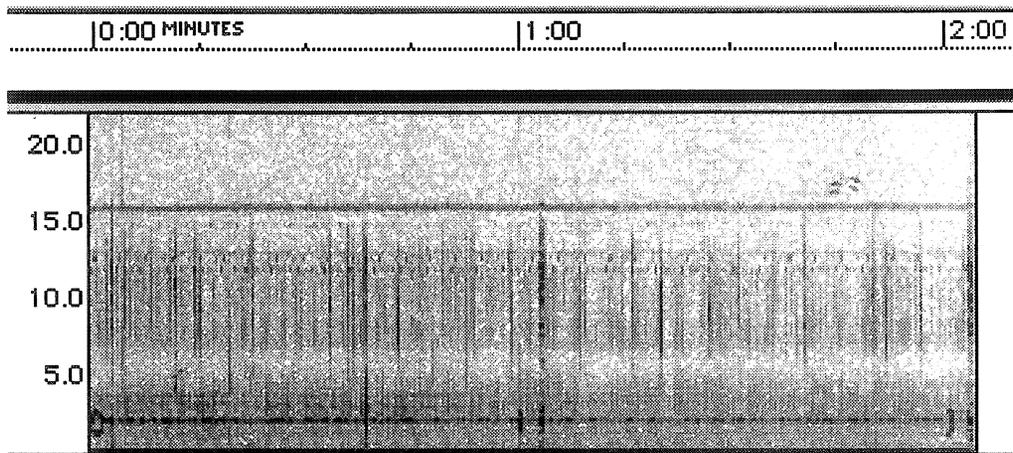
11:00 AM Local; 1000 UT

Note that Alpha is not evident and the signal at 5 kHz persists.

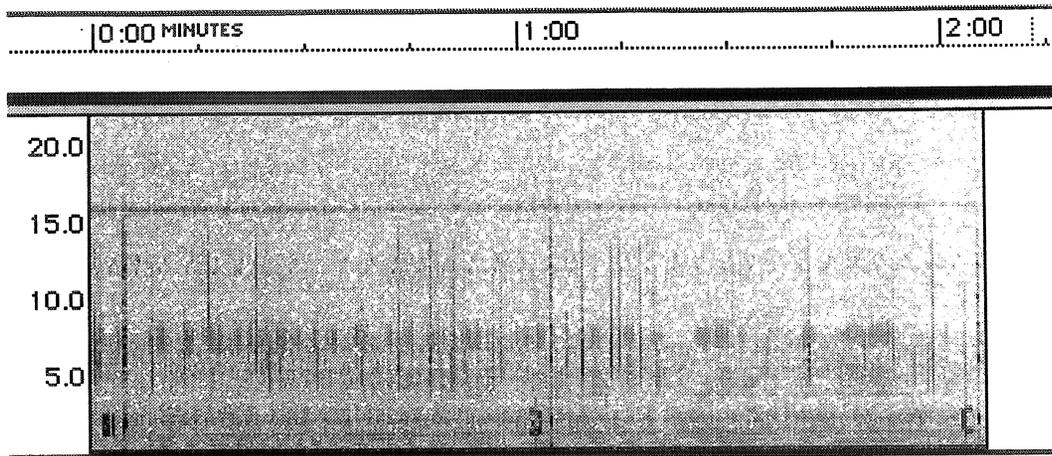
11/29/98



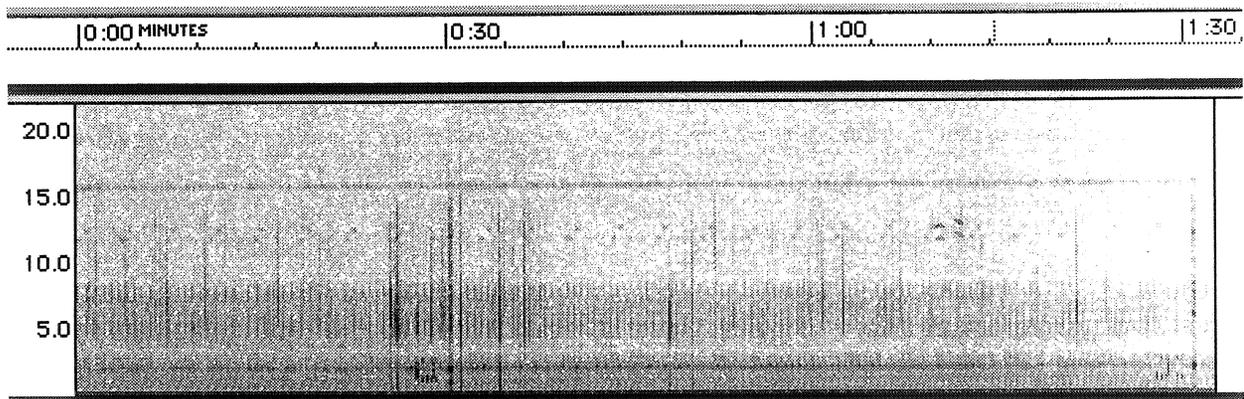
08:00 AM Local; 0700 UT



09:00 AM Local; 0800 UT
Moderate density sferics, strong Alpha and a signal above 15 kHz.



10:00 Local; 0900 UT
 Sferics have increased in density and intensity. Alpha is fading



11:00 AM Local; 1000 UT
 Sferic level is dropping. Alpha still present. 15 kHz signal is down in level.

Notes From the Field

Communications from INTMINS Participants

Edited by Bill Pine
Chaffey High School
Ontario, CA

Data submissions are often accompanied by notes and messages from INTMINS participants describing various aspects of their experiences as observers. As an ongoing feature, some of these communications will be summarized in *The INSPIRE Journal*. The following summaries are in the approximate order in which the data was received by INSPIRE. In addition, some communications will be included from INSPIRE participants who did not record and submit data.

Team 25 Norm Anderson Cedar Falls, IA

Norm observes from George Wyth State Park in Waterloo, Iowa. He reported some intermittent problems with a loud hum on the tape that he was successful in correcting. At the end of the fall season, Norm got a new VLF2 kit which he will assemble and test prior to the spring sessions.

Team 1 Jack Lamb Belton, TX

Jack and his wife, Mildred, are among the most faithful INSPIRE observers. They monitor from a park by Lake Belton. Jack reported that one session was interrupted by the need to explain what they were doing to a group of curious onlookers.

Team 29 Janet Lowry Houston, TX

Details of Observing Session on 11/29/98 at San Luis Pass, TX

San Luis Pass is at roughly 29 degrees N and 95 degrees W. It's 18 miles west of the city of Galveston, and approximately 32 miles south of the Johnson Space Center. It's the place where the West [Galveston] Bay enters the Gulf, spanned by an old toll bridge that connects the western tip of Galveston Island to the next finger of land that curls east from just down the coast.

Tape sessions started at 8 and 9 AM local [Central] time; each 12 minutes long. I was using your receiver with a Radio Shack whip antenna and a Radio Shack model 69 recorder. [This was my first time using this recorder; I had the 'ALC' and 'VOX' buttons switched off.] My observing spot was right at the edge of the Gulf on a deep stretch of beach at low tide, with some power lines perhaps 3/8 or 1/2 a mile behind me along a road. The weather was clear with a moderate wind coming off the water.

Although I intended to record sessions at 7, 8, and 9 AM CST, the 7:00 attempt was a failure when my first observing site turned out to have more humming than a barbershop quartet. I was a bit rattled and discouraged, since I had gotten to the site later than planned because of a bit of coastal and driver fog. Realizing that the site was unproductive, I gathered up [nearly] everything, tossed it in the back, and raced off down the beach for my alternate site. That proved

quieter [and much prettier, too]—although with all of that I wasn't able to set up in time for a 7:00 taping. There were lots of birds and clouds for company, though, and I had plenty of opportunity to watch a brown pelican holding class for an assortment of gulls.

I set up with the receiver taped to my tripod, and had intended to put the recorder on the hood of my little truck. When I did a test, though, there was so much interference that I just set the recorder on a towel under the receiver. I didn't know if using the truck as platform would cause problems. Unfortunately, I had left my grounding spike [my moveable ground] back at the first location, and I didn't realize that until I was many miles down the road. So for the 8 AM session I wound up holding the end of the ground wire, and EVERY time I moved I caused feedback. Actually, the problem seemed to be as much with my headphone wire as with the ground. Although I tried adjusting the data gain several times, I still got a lot of feedback. For the 9 AM session I fastened the ground wire to the screw on the license plate holder of my car; I think that helped a bit. Between sessions I was browsing in one of the articles that you sent me a while back and tried shortening the antenna a bit, just to see if it would help to reduce the feedback, but I don't think that it helped. Because of the feedback that my headphone wire seemed to generate every time I moved, I wound up putting fewer time marks on the 9 AM session—it seemed that the less I moved, the better the sound. [I had the data gain set at about 4, and the volume level of the recorder also at about 4. That seemed to be OK when I was perfectly still.]

Other than the feedback that I seemed to cause, I don't think that I recorded anything out of the ordinary. I didn't hear anything but soft popping and crackling; what I've come to think of as that particular a-rhythmic percussion of the VLF.

I did my time marks in CST because I was afraid that I'd get the UT wrong during the tape. I can see that having someone else along would make the operation go a bit smoother!

Team 18

David Jones

Columbus, GA

I am working during the wee hours, so INTMINS Operation 29-4 fit into my crowded work schedule on a day off. The alarm woke me, as planned just in time to make it to the unused mortar range at the scheduled tape-start time.

When I got to the bridge to Alabama, it was blocked by ambulances and police cars. I had to detour an extra ten-minutes through downtown Columbus, Georgia. I crossed the Chattahoochee River north of downtown and sped south down the west side of the river to the Alabama portion of Fort Benning. Unusual fall weather kept storms far distant and the quarter moon lighted the ground fog over the field. Recently the Army had cleared and bulldozed the field. I set-up the antenna and started recording at what I thought was scheduled T-time: 0627Z. I misread my wristwatch. I started the tape moving at a little after 0624Z, and had preliminary noises and squeaks quieted by 0626Z. I announced the hack wrong as "twenty-seven." The time is actually twenty-six. I heard moderate sferics and some tweaks. I didn't hear the transmission from the MIR. I heard illegal deer hunters and their dogs and a coyote nearer to me than the deer hunters.

The gain of the RS-4 was set at 5, and the recorder gain was 9 out of ten. I took special care to get an unplanned hack at forty-one. This final hack actually occurs at forty. Although I had a WWVB long-wave clock with me, I kept it in the car-trunk lest it radiate at VLF. I corrected my wrist watch before and after the recording. I didn't have time to set up the short wave radio, so hacks are voiced. Conditions were excellent to record the MIR transmission except, evidently, I started the tape too late.

Team 28

Thomas Earnest

San Angelo, TX

Thomas recorded from various sites in his area and the hum levels varied accordingly. While all hum levels were quite low, the lowest seemed to be from a site which included "7200 volt lines 1/2 mile, 169 kV lines 2 miles". On one trip Thomas' wife JoAn served as navigator. For Operation 27-4, Thomas reports:

Team 7**Dean Knight****Sonoma, CA****Sonoma Valley High School**

Dean and his students set up 3 RS4 receivers with different antenna arrangements and different recorders. Receiver "RS" uses a Radio Shack CCR-81 recorder and a 91 foot long wire antenna oriented East-West. Receiver "#62" uses a Bell and Howell Model 3185-A recorder and a 198 foot long wire antenna oriented North-South. Receiver "#65" also uses a Bell and Howell Model 3185-A recorder and a 145 foot long wire antenna oriented East-West. Sonoma Valley High School Team members are indicated below.

	21-3	22-3	29-1		21-3	22-3	29-1
Loni Adams			x	Kendal Jarvis	x	x	
Sarah Barbalesco	x			Stephanie Jensen	x	x	x
Michelle Bertrand		x	x	Erin Klenow	x	x	
Rachel Bowman	x		x	Jullian Krause	x		
Meitra Bozorgzadegan	x	x	x	Mike Kruger	x		x
Jillian Buckley	x	x		Will Kwiatkowski	x	x	x
Ben Casias	x	x		Amy Lind			x
Michelle Costanzo	x	x		Scott Mathison		x	
Teresa Cruz		x	x	Trevor Nuccio		x	x
Amelia Dang	x	x		Stuart Price	x	x	
Ariana DuFloth	x	x	x	Cooper Quentin	x		
Eric Field	x	x	x	Jared Reed	x	x	
Lilly Freeland		x		Gina Rolling			x
Courtney Geissenger			x	Christine Schneider	x	x	x
Alea German			x	Josue Solis		x	
Dana Gillespie	x			Tulley Stroud	x	x	x
Jason Green		x		Abby Swann	x	x	
Annika Gustafsson	x	x	x	Travis Tomiampos	x	x	
Joe Hardeman		x	x	Jennifer Ullman			x
Ty Horner	x	x	x	Heather Watson		x	

Team 30**Linden Lundback****Watrous, Sask., CANADA**

Linden, along with teammate Brian Cowan, submitted this report.

Our team waited in anticipation for the Leonid Meteor Shower observation and data collection on Nov. 17 and 18. The past two weeks were providing solid overcast but an approaching high from the northwest suggested hope for a clear morning. At 1:00 PM local time (0500 UTC) the overcast dissipated to offer a good view of the starry sky. We had a few hours rest hoping the clear sky would remain to offer the possibility of coordinating meteorite viewing to VLF propagation. By 3:00 AM local time, however, overcast conditions prevailed and no visible observations were possible. We continued with the VLF observations at 3, 3:30, 4 and 4:30 local time on Nov. 17 hoping that our data, if relevant, would be compared with meteor sightings at other North American locations. We are looking forward to the next observations with the hope of a clear sky.

Nov. 18 at 12:00 AM proved to be relatively clear and we were hoping for a good meteor show with some associated VLF responses. The meteor show was somewhat thin. We saw about eight all together with three occurring while we were active in the outlined recording sessions. We could not discern any VLF audio response to the meteors.

During portions of the two sessions we ran into an unexplained (to us) VLF emission consisting of a high tone that seemed to grow in strength and many times ended with a flurry of sferics and or tweeks. This process could be compared to that of the noise that the charging capacitors make on a camera flash while it is recharging between shots, the flash fires and the process begins again.

It would be interesting to know if anyone else ran into this occurrence during observations and to possibly find an explanation for this phenomenon. The curious thing is that it did not occur on some of our observation sessions and we did not change any settings of our equipment. It therefore doesn't seem to be an occurrence that can be attributed to a quirk of our equipment or location. (*Eidtor's note: The high tone present intermittently on the tapes sounds like oscillation within the receiver due to the level being set slightly too high. This will appear intermittently since it is a response to high amplitude sferics and other signals.*)

There were many sferics and tweeks during our recording sessions. The ones that seemed to be more prominent, I have noted on our log sheets. I have also logged the unexplained tone with a (u) on our logs. We did note one whistler at 06:33:04.

Our team hopes that observations from the Great White North will provide some useful information and we are looking forward to the coming [INTMINS and ISTOCRNIK observation sessions.

On Nov. 20 (Nov. 21 UTD), we attempted to pick up some relevant information from the MIR Istochnik firings. The first session provided lots of sferics and tweeks but no discernible tones. The second session provided much of the same with a few whistlers possibly detected.

We wanted to participate in one European firing hoping that the tones would propagate over the pole to our location. We chose a firing that occurred as close to 180 degrees longitude from our location as possible and therefore chose E27-2. The time of the firing did not allow the selection of a reasonably quiet location so we had to set up a few miles from the town of Watrous near our place of work. The site proved very noisy with AC and AM radio broadcast interference from a 50 kW transmitter operating at 540 kHz. Initially we thought the session was a wash but a few whistlers coincidentally (?) occurred near the proposed firing time and we thought we might have picked up a VLF response to the firing.

After work, we looked for a quieter site for the 28-2 firing and found a reasonably good one. The evening was beautiful and clear. The radios were set up with time to spare so we were able to enjoy the stars and a couple of cups of hot chocolate while waiting. There were a great deal of spherics and tweeks during the session and some coincidental (?) whistlers, again close to the proposed ISTOCTMK firing time which strengthened our feeling that the whistlers may be a VLF response to the test firing.

Other commitments prevented us from participating in the Intiniis sessions but we hope the enclosed data will provide some insight to Inspie's VLF studies.

Team 21

Phil Hartzell

Aurora, NE

Phil has a plug for the University of Nebraska at the top of the stationery for Hartzell Auto Interiors. He then reports on some work with loop antennas.

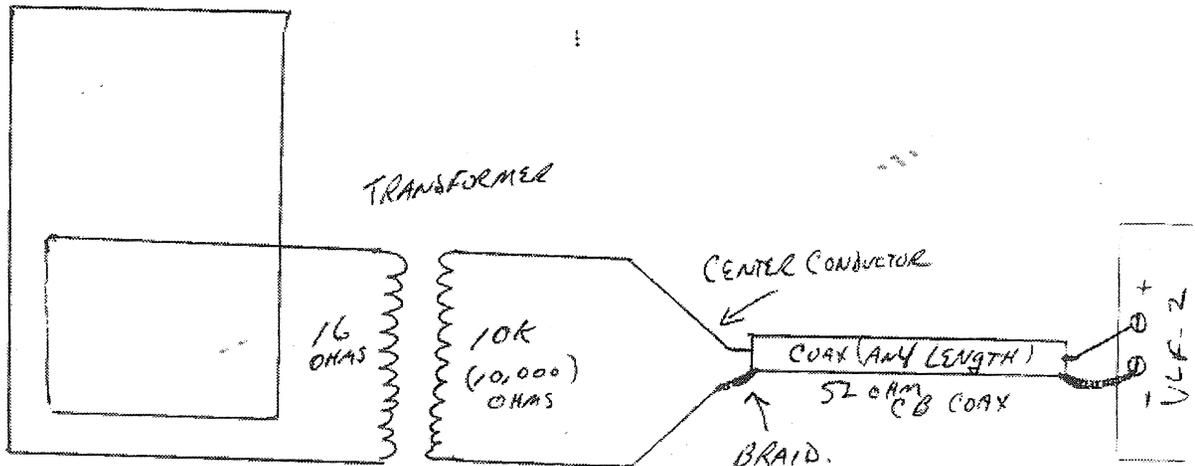
"Home of the National Champion Nebraska Cornuskers
1970 .. 1971... 1994 .. 1995 .. 1997..One for Solich in 99!"

The weather in this area of the country for Leonid was a bust. I had about a week of cloudy weather before and after the maximum for the shower. The sun did pop out for a few days in the afternoon, (of course). That is typical for Nebraska as the fall turns towards winter and the temperature begins to drop. My recording sessions were very typical for the time of year. Not too much activity, quite a drop compared to summer evenings when levels are much higher. Which at times becomes overpowering and covers some good whistlers

I recorded my sessions this winter on a new loop. I dropped the sides of my loop to 3 foot square and added some turns. I now have 112 turns. This is 450 feet of wire. Wind it side by side, but not super neat. It doesn't need

to be perfect like a coil out of a radio. I made a wooden frame. You can use a cardboard box as a form if you leave the ends on for sturdiness, but don't get it wet! I also changed the transformer from 10 k - 8 ohms to 10 k - 16 ohms. The new transformer has closer coupling match from the loop to the VLF-2. The signal levels are quite a bit higher so I need to turn down the gain level on the VLF-2. The 16 ohm side goes to the two free ends of wire on the loop and the 10 k side goes on my center conductor and braid of my coax. The coax runs to the VLF-2. Connect the braid of the coax to the negative side of the VLF-2 input, and the center conductor to the positive side of the input. All we are doing is tricking the receiver into seeing a high impedance load on the input end at the receiver. The receiver will not work for a loop connected directly to the input. The impedance is too low. But if we put a simple transformer in line and change it, the receiver doesn't know the difference. Why did I use a 10 k to 16 ohms? Because it was in my junk box. I had about a dozen to experiment with. I alligator clipped them in (one at a time) and cand checked signal levels in the field. I found the 10 k to 16 gave me the best signal and the best null when I rotated the loop. You can experiment with different values to find the one that works best for your application. Simple audio transformers are found at Radio Shack for just a few bucks.

I have also noticed an effect of a portable loop. I have found that I need to hang it from a tree branch at least a few feet off the ground. When I do set it on the ground, it picks up much more AC hum. Set it on a wooden picnic table, or maybe a wooden painters easel. Rotate it so you have the least AC hum. The more turns on your loop. the sharper the null My loop works best when the broad side is east and west, which means the wires run north to south. Keeping the loop perpendicular to the ground is best. I have enclosed a drawing showing the basic configuration.



MULTIPLE TURNS
NOT SHOWN FOR
CLARITY.

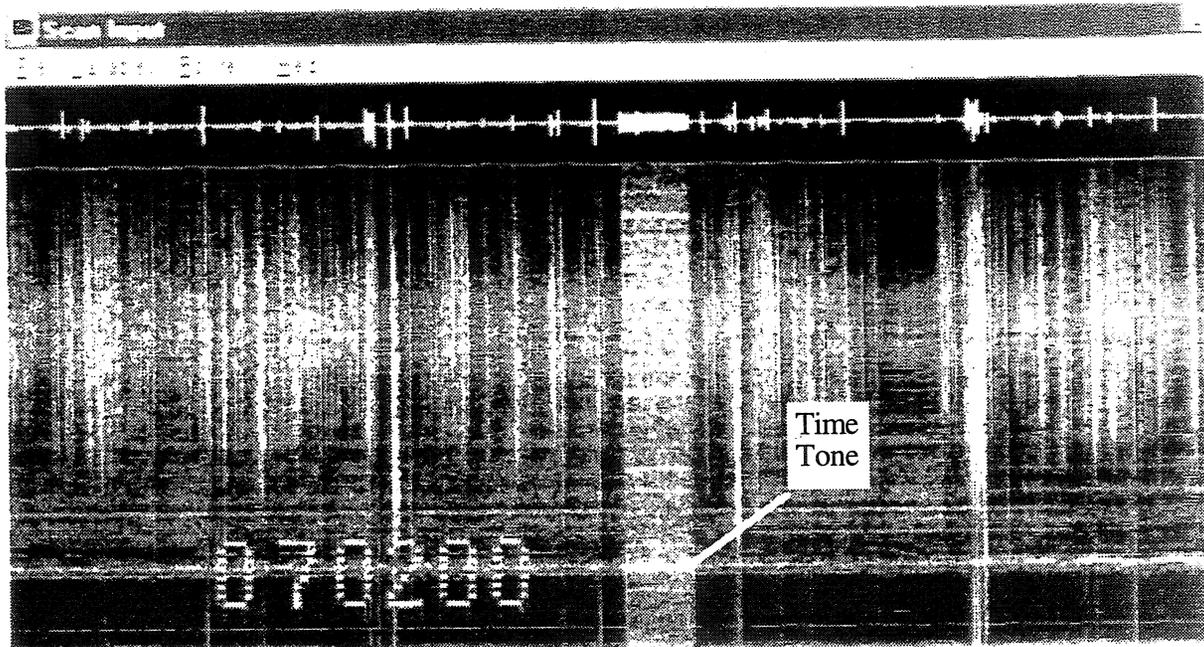
112 TURNS - 3 FT
PER SIDE OR
ABOUT 450 FT.

Team E5 • Renato Romero

Cumiana, ITALY

Renato used Mike Aiello's ATM (Automatic Time Marking) software to put time marks on his data. Renato modified the software to include signals on the tape that are read by the analysis software and displayed on the spectrogram as digital time marks. the signal sounds like a musical ringing on the tape and can be read by either type of analysis software used in INSPIRE: GRAM

for the PC and Soundedit 16 for the Mac. Elsewhere in the *Journal* are examples of the output from Soundedit. Below is a sample sent by Renato of the output from GRAM.



The time stamp is followed by a tone also generated by the ATM software.

Team E2

Silvio Bernocco

Torino, ITALY

Silvio did some of the most precise and well documented Leonid observations. His monitoring location has a high level of manmade hum, but natural signals are still easy to hear and find on the spectrogram. He also included some narrative notes which appear below.

November 16-17, 1998

2200 - 0200 Local Time

Many meteors; scattered radio activity on VHF radio amateur bands.

On 144 Mhz, many contacts with Northern europe, Scandinavia, Russia, United Kingdom.

The shower has started.

November 17, 1998

0330 - 0730 Local Time

Imposing astronomical event on a clear night.

By tens, bolides and meteors were seen ranging in azimuth from about 20 degrees to 270 degrees.

I centered my observations in the Orion direction with low light pollution.

On the 50 Mhz radioamateur band, 6 European beacons were heard including strong signals from U.K.

0400 - 0500 Local time

High bolide activity. Two bolides lit up the land around me like a camera flash.

Other bolides left long trails remaining in the sky for some minutes.

I could see the slow wrap of the trail from a straight line.

0500 - 0600 Local Time

Minor bolide activity, many meteors.

0600 - 0700 Local Time

In the dawn, many bolides with rainbow colored tails.

November 17 - 18, 1998

1800 - 0130 Local Time

On a clear night, I observed only 3 meteors. VHF bands were close.

I called a long time on 50 Mhz, but no meteor scatter signals were heard.

People reported to me that some meteor activity occurred between 0500 and 0700 local time.

Team 4

Mike Aiello

Croton, NY

Here is my tape from November, along with my hand-written tog. Unfortunately I did not have time to re-type everything, so I hope you can read my notations. Also, I'm not sure if there is still time to include my observations in the Journal - if not, I apologize for taking so long to get them to you.

This particular recording session (28-8) was just a Lovely evening to be out overlooking the Hudson River. It was clear, mild, and just before local sunset. As I was recording, I saw MIR appear out of the southwest, climb to the zenith and pass nearly directly overhead, and then disappear to the northeast, behind the hill above my recording site. It was quite an INSPIRE-ing site!

I didn't hear anything out of the ordinary on the tape. For a period of a few minutes during the session, starting around 22:25:25, my headphones were either causing or picking up audio feedback of some kind, so I disconnected them. Two episodes of loud feedback appear on the tape around this time.

I did want to mention my VLF web page, which can be found at

www.marymt.edu/~aiello/vlf.html

I have some illustrations and photos, a short VLF sound clip, and Links to VLF related material. There is also a page where you can download my Audio Time Marker program for Windows.

Renato Romero, who is apparently using the ATM program, has made a set of sound files which actually add the time stamp to a sonogram as a set of six "dot-matrix" style digits. This sound file set is also available for downloading from my web site.

Team 6

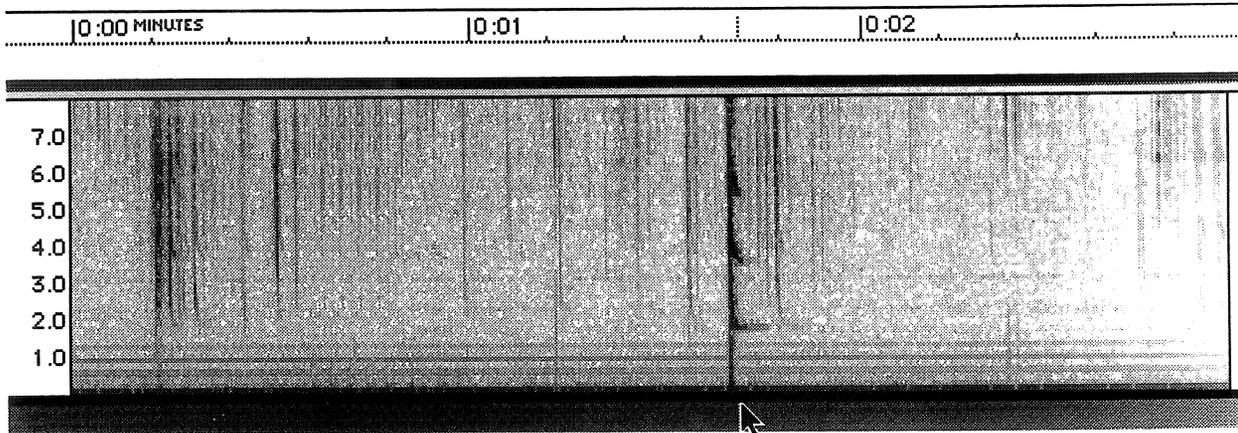
Bill Pine

Ontario, CA

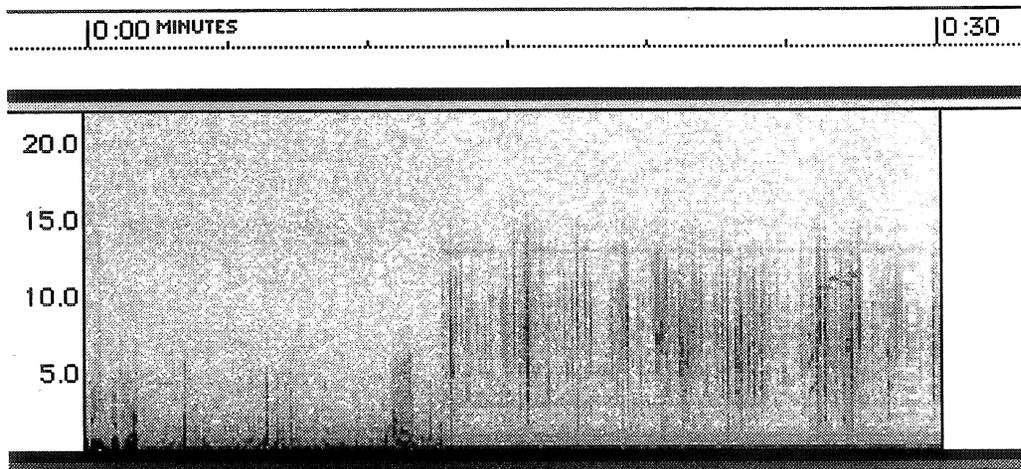
Chaffey High School

The Chaffey High School INSPIRE team set up three receivers for observations at our site on Glendora Ridge Road in the San Gabriel Mountains overlooking our valley.

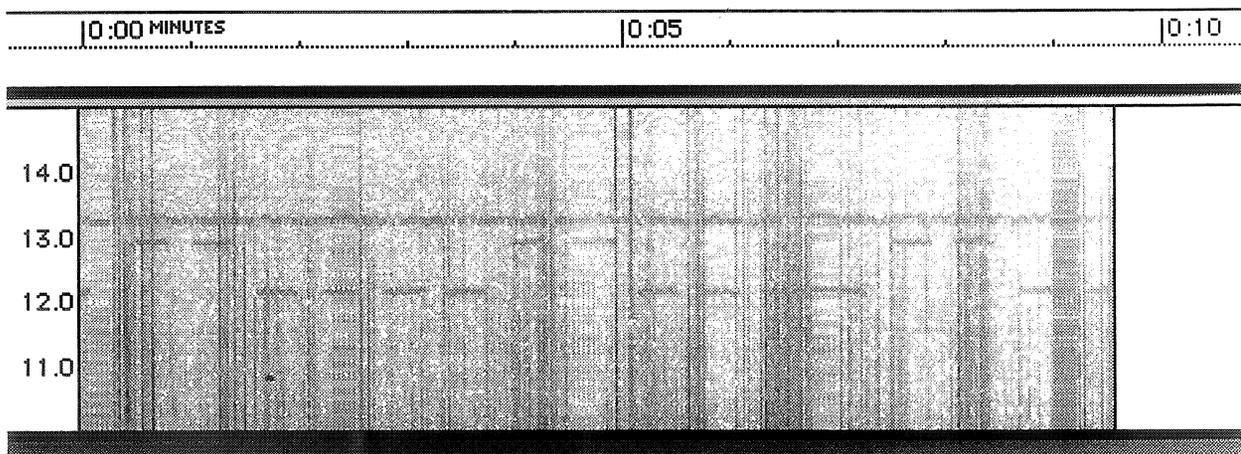
Receiver #1 is an ACTIVE B-field receiver from the first project in 1989 that eventually became INSPIRE. The antenna is a center-tapped 1-meter square loop antenna with 90 turns. The recorder is a Radio Shack CTR 69. Ivan Seigneur captured several interesting tweaks during Operation 21-3.



Ivan Seigneur, Receiver #1, Operation 21-3
 Strong tweek with the "hook" at 1.8 kHz and harmonics above that.

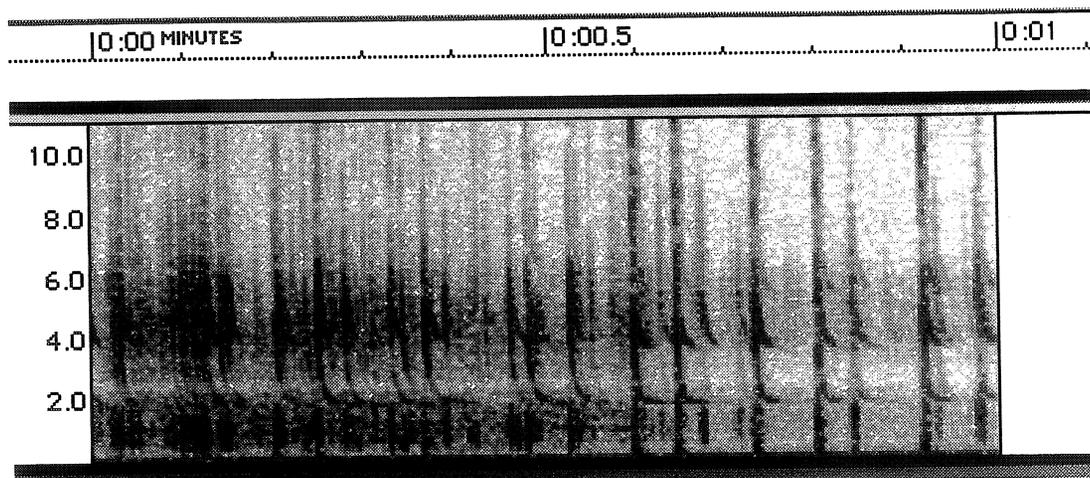


La Reina Whatley, Receiver #1, Operation 22-2.
 Alpha appears a smudges between 10 and 15 kHz.

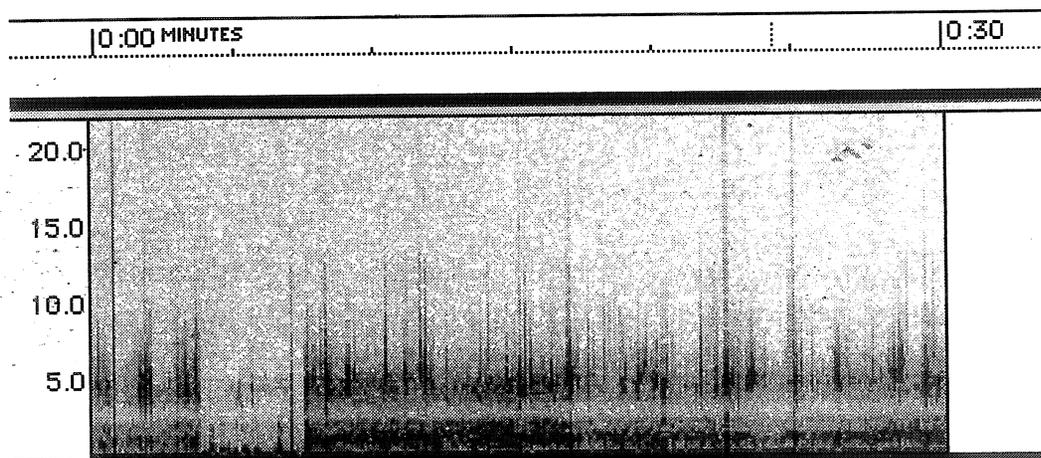


Andre Oullette, Receiver #1, Operation 28-1.
 Alpha appears prominently on this receiver.

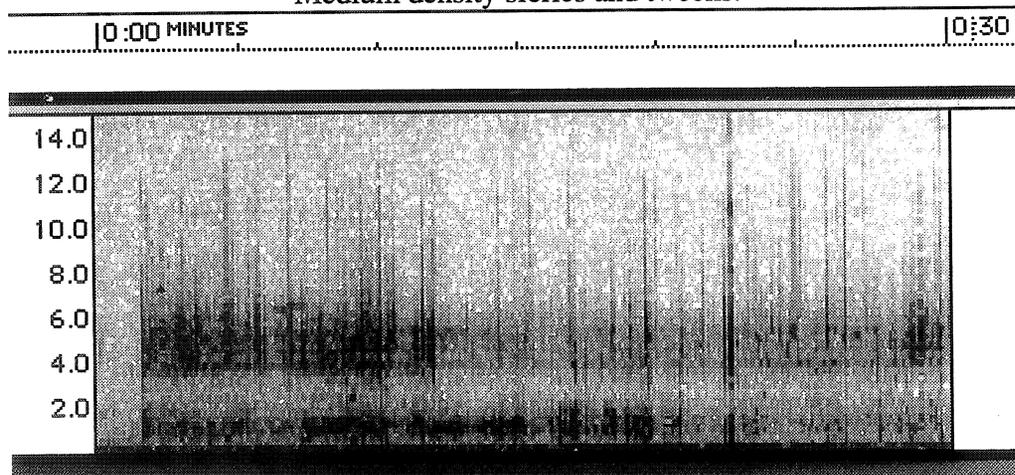
Receiver #2 is an INSPIRE RS4 using a 2-meter whip antenna. The recorder is a Toshiba Walkman-style portable.



Andre Ouellette, Receiver #2, Operation 21-3.
A burst of tweaks showing at least 10 strong tweaks and many weaker ones in one second.

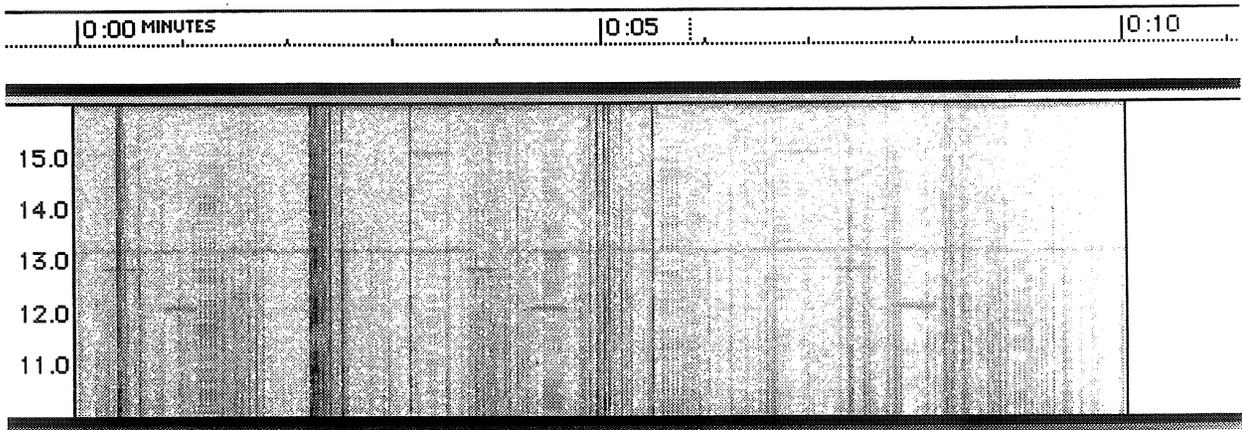


Daniel Silva, Receiver #2, Operation 22-2.
Medium density sferics and tweaks.

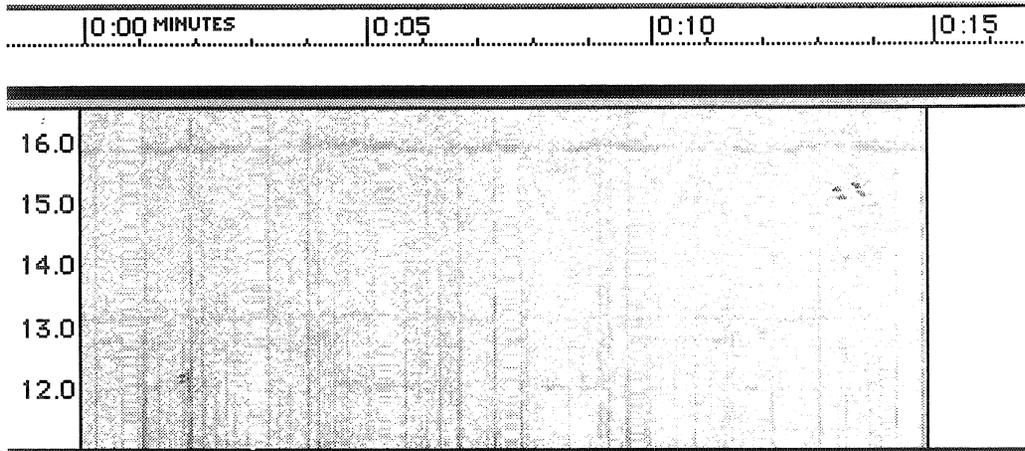


Daniel Silva, Receiver #2, Operation 28-1.
Higher density and amplitude on these sferics.

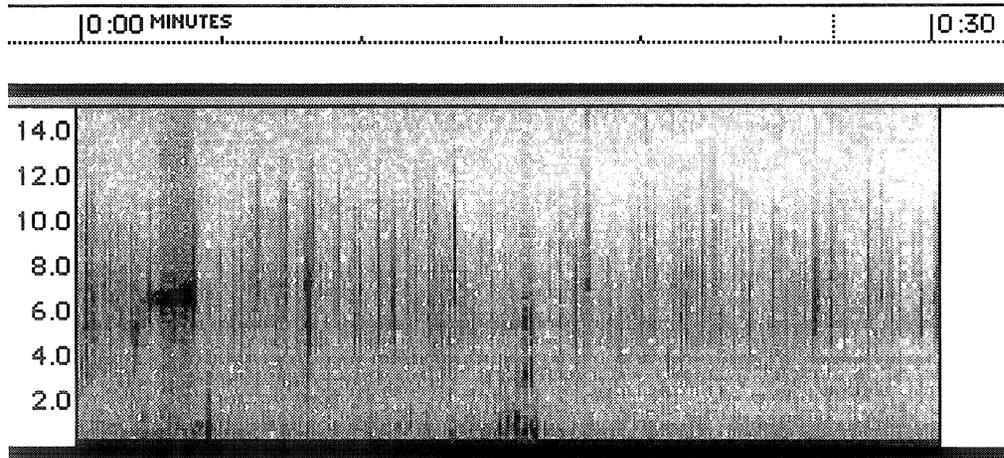
Receiver #3 is an INSPIRE VLF2 receiver using a 2-meter whip antenna. The recorder is a Marantz PMD 430 portable cassette recorder.



Vince Mangione, Receiver #3, Operation 21-3.
Alpha signals appear as dashes at three frequencies.



Vince Mangione, Receiver #3, Operation 22-2.
Alpha signals faintly visible (and audible) at 12 kHz and above.



Megan Souter and Eric Reed, Receiver #3, Operation 28-1.
Signal at about 4 seconds is oscillation in the receiver.

INSPIRE Observer Team _____ Receiver _____

Operation _____

Date _____ Tape Start Time (UT) _____

Operation details: Tape start time: _____ UT _____ local

Operation start time: _____ UT _____ local

Operation type: _____

Operation stop time: _____ UT _____ local

Tape stop time: _____ UT _____ local

Equipment: Receiver _____ WW V reception: _____

Recorder _____

Antenna _____

WWV radio _____

Site description: _____

Longitude: _____° _____' W Latitude: _____° _____' N

Local weather: _____

Personnel: _____

Team Leader address: Name _____

Street _____

City, State, Zip, Country _____

