The INSPIRE Journal

Volume 1 Number 1 October 1992

Editor: Bill Pine

Welcome to The INSPIRE Journal! This is the first of four scheduled issues of the Journal. I had originally intended for the Journal to be a quarterly, but since the next flight of a shuttle based VLF transmitting device seems to be at least two years off, it makes more sense to publish two times per year over the next two years. Publication dates are tentatively set for October 1 and May 1, with the deadline for contributions one month prior to these dates.

The content of the Journal will depend largely on the contributions of the readers. Your input is needed to determine what you would like to see included. Your contributions are vital to the success of this publication. Articles are sought dealing with any area connected with VLF observations and research. Topics may include, but are not limited to: field reports of your experiences in VLF monitoring, receiver modifications and electronic equipment design, reports on literature research, and anything else you can imagine. Please submit your efforts in copier-ready form and I will be happy to publish what you send in. Articles written by students are especially welcome!

This first issue starts off with some brief items from the editor and continues with some articles contributed by INSPIRE participants.

VLF Operations - Fall 1992

Due to the difficulty in finding data analysis facilities, it has been decided to have no coordinated listening operations this fall. The long term plan is to conduct coordinated listening on a prescribed schedule each fall and spring with data analysis services available at a reasonable cost. That plan will have to wait until data analysis capabilities are more widely available.

In the mean-time, continue to monitor VLF emissions and submit your field reports to the Journal. (See the article "Fall '92 Operations at Chaffey High School".) Through written logs and reports we can share our experiences and improve our procedures and techniques. Please limit the length of your report to one page and submit it in copier-ready form.

Data Analysis Software

Efforts to find data analysis software for the IBM continue. INSPIRE is currently talking with other scientists about the possibility of contracting with them to develop the software for INSPIRE. If we are successful in developing the software in this way, we will be able to make it available to INSPIRE participants and other interested individuals. At the present time this project is just beginning, but we will keep you posted.

MacRecorder has been upgraded to MacRecorder Sound Edit Pro, with a significant increase in speed and features. The educators' discount price is now $175. MacRecorder Sound Edit Pro can be purchased from local dealers. To find a dealer near you, call Academic Computing Specialists at (800) 552-1601. Ask for ACS Part Number MM4071M.

Orbit Tracking Software

Two orbit tracking programs have been made available through INSPIRE: STS Orbit for the IBM and MacSPOC for the Macintosh.

The STS Orbit program is still available from INSPIRE for $10. This program includes on-disk documentation. Please specify 3.5" or 5.25" format.

MacSPOC was offered through a license granted to INSPIRE by the author, Dan Adamo. This license has expired, but the software is still available directly from the author:

Daniel R. Adamo
4203 Moonlight Shadow Court
Houston, TX 77059

Phone: (713) 480-9631

INSPIRE T-shirt Sale

There are a few INSPIRE T-shirts left. The price has been reduced to $12 per shirt while supplies last. If you order three or more shirts, the price is $10 per shirt. Sizes available are M, L, XL and XXL. Colors available are black with white logo and white with black logo. Specify sizes and color preference when you order. The black shirts are in short supply. When you order black shirts, please indicate if you will accept white if the supply of black is exhausted. Send orders to Bill Pine at the address below.

The INSPIRE Photo Album

Included in this issue is the first installment of the INSPIRE photo album. If you would like to submit a picture for inclusion, please send a print <u>and</u> the negative. Include a self-addressed stamped envelope for the return of your print and negative. Be sure to write a caption to accompany your picture.

Orbit Tracking Maps

In an earlier communication I passed on a question that I did not know the answer to: Where can we get a map of the projected orbit of a particular shuttle mission? A couple of people wrote with the answer and one person sent a copy of a NASA publication, "Shuttle Prediction and Recognition Kit (SPARK)". SPARK is a paper and pencil orbit tracking exercise that includes an orbit map and uses the launch time, orbit period and orbit inclination to allow the computation of the time of "favorable orbits" for viewing and tells you when and where to look for the shuttle. The activity looks appropriate for junior and senior high school students, but I would not bet against elementary school students getting a lot out of this with proper supervision. I have not field tested the material yet, but I intend to incorporate this with our VLF observations during the next shuttle mission.

SPARK kits can be ordered from:

SPARK
AP4
NASA Johnson Space Center
Houston, TX 77058

RS-4 Receiver Kits

Sixty four kits were shipped in late August. This shipment filled all of the orders received by the deadline stated in the offer. There are no more kits available. We are redesigning the receiver circuit and will offer kits again in the future - probably in association with the next mission (in about 2 years). I will keep you posted.

Questions and Contributions

Questions and contributions for the INSPIRE Journal are invited. If you would like your questions answered separately, please include a self-addressed stamped envelope (SASE) and I will answer your question by return mail. If you do not include an SASE, I will assume that you want your question answered in the next issue of the Journal. Send all questions and contributions to:

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The INSPIRE Journal

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Artificial Auroras in the Upper Atmosphere

1. Electron Beam Injections

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Abstract

Artificial electron beams from the Space Experiments with Particle Accelerators (SEPAC) on the Atlas-1 Spacelab payload were used to stimulate auroral emissions at southern auroral latitudes. The emitted electron beams were monoenergetic at 6.25 keV and were fired in one-second pulses every fifteen seconds with currents of 1.21 A. Optical measurements of the beam were made in the vicinity of the Shuttle Orbiter by its on-board television camera and in the upper atmosphere by the Atmospheric Emissions Photometric Imager (AEPI). AEPI imaged auroral emissions in both white light and at the 4278 Å N_2^+ emission line. Energy deposition calculations and the results of previous sounding-rocket experiments had suggested that emissions with scale sizes of about 130 meters would result from the artificial electron beams with the visible emissions extending from about 110 to 130 km altitudes. In the Atlas 1 experiments the auroral imaging was perfomed from the Shuttle, providing a new perspective on the artificial auroras and allowing the emissions to be traced from altitudes near the 295 km Shuttle altitude down to the 110 km level along the curved magnetic field lines.

Introduction

Gaining an understanding of Earth's natural aurora will require a multifaceted experimental and theoretical approach. The dynamical nature of the aurora and the tendency for many important phenomena to occur together have made it difficult to determine the relative roles of the magnetosphere and the ionosphere in triggering auroral displays and in determining the sources and closure of the field-aligned currents associated with them. A summary of contemporary problems that define auroral physics is provided in the book by Meng et al. [1991]. Measurements of the fields and plasmas associated with the aurora need to be made at higher temporal and spatial resolution, and ultimately at multiple locations simultaneously, in order to characterize sufficiently the auroral particle acceleration processes. Of particular interest is the auroral acceleration region, which is located at altitudes of an Earth radius or so along the magnetic field lines threading the aurora; sounding rockets and satellites with increased capabilities are contributing significantly to the investigation of the auroral acceleration region. A complementary approach involves the use of artificial electron beams either to stimulate auroral displays in quiet regions where an unambiguous input-output experiment can be performed or to sense remotely auroral phenomena such as parallel electric fields as they occur naturally.

The Space Experiments with Particle Accelerators (SEPAC) were conducted as part of the Atlas 1 Spacelab mission from March 24 through April 2, 1992. One of the objectives was to perform artificial aurora experiments from orbit using high-power electron beams and the optical imaging capability of the Atmospheric Emissions Photometric Imaging (AEPI) instrument [Mende et al., 1992]. The SEPAC electron beam accelerator (EBA) is capable of injecting electrons with beam energies up to 6.25 keV. At this energy the perveance-limited electron gun can emit beam currents of up to 1.21 A, giving a beam power of 7.56 kW. The previous flight of SEPAC on Spacelab 1 [Obayashi et al., 1984] showed that at these levels special means of neutralizing the Shuttle spacecraft are necessary; therefore, for Atlas 1 the SEPAC instrument complement included three 122-cm diameter conductive spheres for charge collection and a 1.6 A hollow-cathode Xe^+ plasma contactor. The flight data show that the effectiveness of these charge neutralization devices was sufficient for injection of electron beams up to the highest beam currents available with the SEPAC EBA.

Artificial auroral experiments had been conducted previously from sounding rockets [Hess et al., 1971; Davis et al., 1971, 1980; O'Neil et al., 1979]. See also the comprehensive review by Winckler [1980]. The results of the previous experiments led to the expectation that the SEPAC EBA, at highest power, would produce an artificial aurora characterized by an emission with a diameter of about 100-150 m at altitudes of 100-120 km. However, because of the favorable viewing geometry from orbit, the artificial aurora emissions were imaged over the full extent of the curved magnetic field lines from near the Shuttle altitude of 295 km down to the 110-120 km altitude regime. Also present in the images were afterglows, which appeared as emission "tails" extending up to ~1 km in the wake direction. Contrasts between SEPAC and the previous experiments include the facts that (1) the optical measurements were made from the same spacecraft from which the electron beam was injected rather than from the ground or aircraft, (2) total charge neutralization was accomplished with the charge-collection spheres and the plasma contactor; and (3) the artificial auroras were produced in the auroral zone and in the neighborhood of natural auroras.

Experiment Description

SEPAC is a joint U.S.-Japan investigation of the interaction of electron beams, plasma and neutral gas with the Earth's upper atmosphere, ionosphere and magnetosphere. It makes use of the large mass, volume and power capabilities of Shuttle/Spacelab as well as the interactive control that is possible through the involvement of payload and mission specialists. The first flight of SEPAC was with the Spacelab 1 mission (STS-9) in late November and early December 1983. Recently an upgraded instrument complement was included as part of the Atlas 1 payload on STS-45 in late March and early April 1992. The upgraded SEPAC instrumentation is described by Taylor et al. [1990]. Table 1 shows the SEPAC instrument complement as flown on the Atlas 1 payload.

Table 1. SEPAC Instrumentation for Atlas 1

Instrument	Parameter	Range
Electron Beam Accelerator (EBA)	Energy	0 to 6.25 keV
	Current	0 to 1.21 A
	Perveance	2.5×10^{-6} $AV^{-1.5}$
	Initial Beam Diameter	20 mm
	Deflection	0 to 30° from axis
	Modulation	≤ 5 kHz
Xenon Plasma Contactor (PC)	Ion-electron production rate	1.6 A
	Operation time available	1500 hrs.
	Neutral gas pulse width	100 ms (programmable)
	Number of ejected atoms	~6×10^{22} per pulse
Low-frequency plasma wave probe	Frequency	0.75 to 10 kHz
High-frequency plasma wave probe	Frequency	0.1 to 10.5 MHz
Wideband plasma wave probe	Frequency	0.4 to 10 kHz 0.1 to 4.2 MHz (or 4.0 to 7.5 MHz)
Floating probes	Distances from pallet	290 mm, 540 mm, 790 mm
	Frequency	0 to 400 Hz
	Potential	-8 kV to +8 kV

	Resolution	6 V
Energetic Electron Analyzer	Energy	0.1 to 15 keV
	Energy resolution	$\Delta E/E = 0.18$
	Angular acceptance	4^o by 10^o
	Sample rate	100 Hz
	Energy sweep time	320 ms
Langmuir probe	Density	10^4 to 10^8 e cm^{-3}
	Temperature	600 to 5000 ^oK
	Sample rate	1 kHz (current) 250 Hz (voltage)
Ionization gauge	Pressure range	5×10^{-8} to 5×10^{-4} Torr
	Sample rate	1 kHz

During the artificial aurora experiments the plasma contactor (PC) was operated continuously so that up to 1.6 A of Xe^+ ions could be ejected to balance an equal current of electrons from the EBA. Since for Atlas 1 the EBA current was limited to 1.21 A, the PC had more than sufficient output current capability to maintain charge neutrality during the most intense electron beam injections. The neutralization process was aided by the charge collection spheres and the Shuttle conductive surfaces (the engine bells and the inner surfaces of the payload bay doors), which can effectively collect ionospheric electrons along magnetic field lines.

Figure 1 demonstrates the ability of the plasma contactor to neutralize the Shuttle/Spacelab during electron beam injections. Figure 1 shows the spacecraft potential as measured by the three floating probes, the EBA current and voltage, and the PC current. The floating-probe data in Figure 1 show that the spacecraft potential did not rise more than about 5 V during the beam firings. Also providing evidence of spacecraft neutralization and of the fact that no beam-plasma instabilities or discharges disrupted the beam during the artificial aurora experiment is the image of the beam in Figure 2. This image was taken in white light by the on-board low-light television system provided by the Shuttle Orbiter. The beam was not visible in the TV data except when neutral and ionized Xe were simultaneously released from the PC. Figure 2 clearly shows the first spiral of the beam in the geomagnetic field as the beam was fired upward at 5 keV and 500 mA. The dark central segment of the beam is produced by saturation of the TV camera, indicating the most intense part of the beam. The spiral in Figure 2 is located about 200 meters above the Shuttle.

Artificial Aurora Experiment

In each of the three artificial aurora experiments that were performed on Atlas 1, twenty electron beams were injected downward from an altitude of 295 km with 0^o pitch angle at relatively high southern magnetic latitudes (65-67^o). During the first and third experiments,.optical observations were made with the AEPI instrumentation. In the first experiment white-light images were acquired at a rate of 30 Hz, while in the third experiment these high-rate white-light images were supplemented by images at 4278 Å, which were integrated over 1 second. The electron beam pulses were injected once every 15 seconds at the maximum energy and current (6.25 keV, 1.21 A) with pulse widths of 1 second.

Figure 3 shows two consecutive 4278 Å images that were obtained 30 seconds apart in the southern auroral zone during the third artificial aurora experiment. High-time-resolution white-light images of the artificial aurora are discussed by Mende [1992]. In Figure 3a the artificial aurora is located in the dark region near a quiet auroral arc, while in Figure 3b the artificial aurora is superimposed upon a naturally occurring quiet auroral arc. Each artificial aurora image contains significant spatial structure, the most persistent features being a tapered extension toward the bottom of the image and (particularly noticeable in Figure 3a) a trail in the Shuttle wake direction, possibly indicating an afterglow phenomenon. The travel time of the beam to the 110 km level is only about 5 ms, and the 4278 Å emission is prompt, with a lifetime of <1 μs; therefore, the wake trail was not predicted. The afterglow present in the wake trail may have been produced by induced electron precipitation, caused perhaps by an enhancement of ionospheric Pederson conductivity produced by the artificial beams, although this possibility needs to be investigated further.

The tapered extensions toward the bottom of the images in figures 3a and 3b are produced by the curvature of the magnetic field line. For this experiment the Shuttle was moving generally eastward, or to the left in figures 3a and 3b, so north and south are toward the top and bottom of the figures, respectively. The AEPI has a field of view of 20^{o}, so at 110 km the width of the images in Figure is about 80 km. The displacement of a dipole field line at a magnetic latitude of 65^{o} between 295 km and 110 km because of field-line curvature is about 1.8 km, which is consistent with the images in Figure 3. The bottom tip of the downward tapered extensions in Figure 3 is, then the lower extension of the artificial aurora at altitudes of about 110 km. Detailed analysis of the images is reported by Mende et al. [1992].

To our knowledge no other artificial aurora experiment has been conducted in the auroral zone with currents as high as 1.21 A at typical auroral electron energies. Future experiments are needed to take advantage of the much greater detectability of the artificial aurora emissions from orbit in performing more extensive spectral analyses and in using the artificial electron beams to sense remotely electric fields in the auroral zone. The fact that the artificial auroras are easily detectable even when superimposed on bright natural auroras supports the possibility that upward-propagating electron beams, reflected by parallel electric fields above the aurora, would produce detectable artificial auroras, which could be used to map the strength and spatial distributions of the parallel E-fields.

Acknowledgements

Many people have contributed to the SEPAC experiment over the years. Professor Tatsuzo Obayashi, who is recently deceased, was the original principal investigator beginning in 1976. Bill Tomlinson and George Ferguson of SwRI and Randy Bounds of

Nichols Research contributed extensively to the hardware and software efforts. At ISAS numerous scientists and engineers contributed to SEPAC, including Drs. K. Kuriki, M. Nagatomo, K. Ninomiya, and M. Ejiri. We have benefitted greatly from the involvement of co-investigators Dr. Rick Chappell and Professor Peter Banks; the Atlas-1 crew; the Atlas Project personnel, under the guidance of Tony O'Neill of MSFC, and Dr. Bob Beattie of Hughes Research Laboratory.

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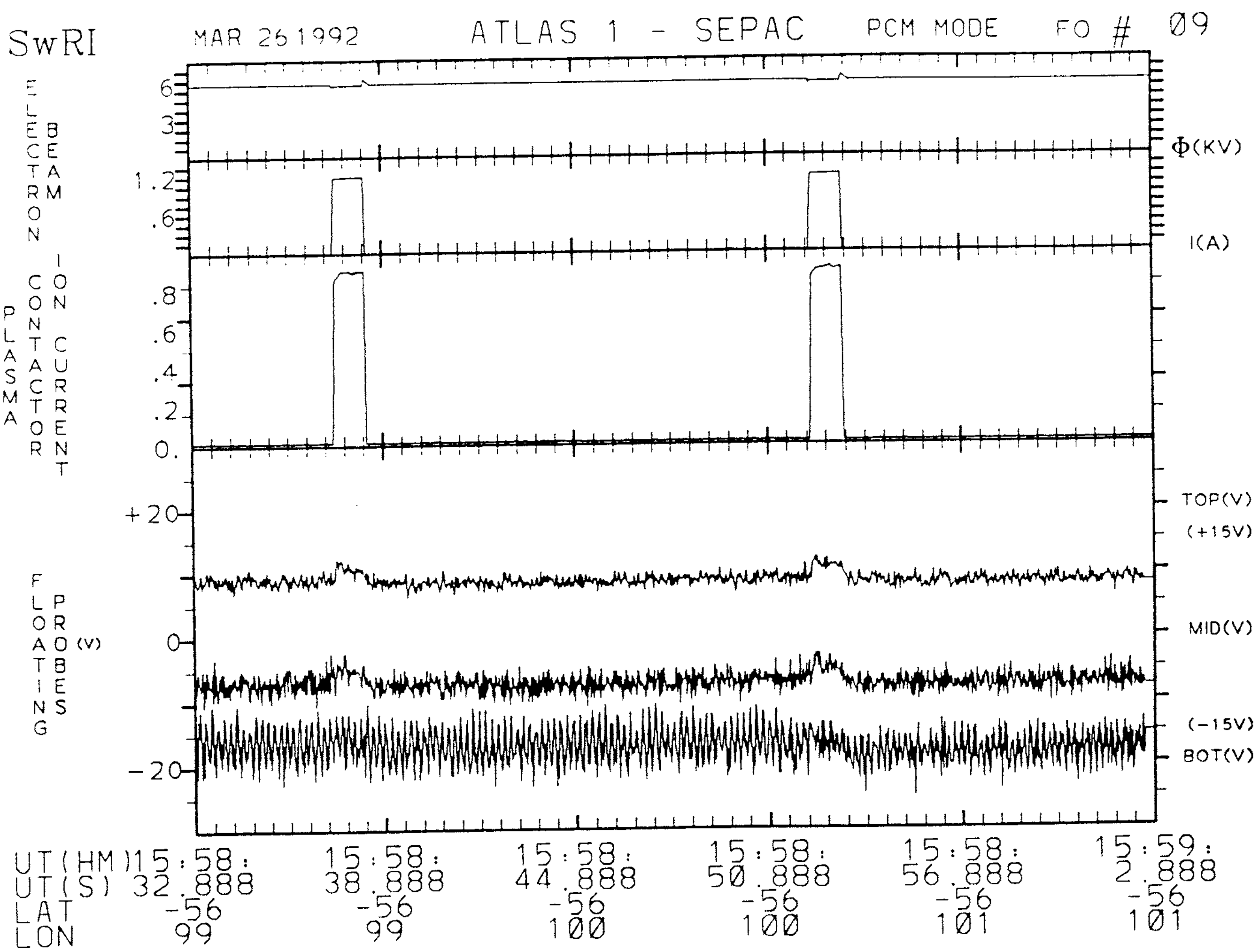


Figure 1. A 30-second plot of the EBA voltage and current, the PC ion current, and the three floating-probe potentials in the top to bottom panels, respectively. The PC ion current is plotted in normalized units pending final monitor calibration. The floating-probe potential traces are separated by 15 V to avoid overlap.

Figure 2. Image from an Orbiter payload-bay television camera of a SEPAC artificial electron beam with energy of 5 keV and current of 500 mA. The beam was rendered visible by the injection of a neutral Xe pulse (see Table 1), which was excited by the electron beam. The dark central region of the beam is a saturation effect. The first spiral of the beam in the Earth's magnetic field, which is evident near the end of the visible beam, was located about 200 meters above the Orbiter. The illuminated object in the lower right hand corner of the image is part of the payload bay instrumentation.

Figure 3. (a) Artificial aurora image in 4278 Å. To the left is a quiet auroral arc; in the upper right is the artificial aurora. The image was obtained by the AEPI instrument [Mende et al., 1992], which viewed downward along the magnetic field direction, during a one-second period beginning at 16:01:59 UT on March 26, 1992. The direction of motion of the Shuttle Orbiter was to the left, so the natural auroral arc is broadened in the horizontal direction by about 10%. The width of the image at the 110-km level is about 80 km. The color bar is linear from top to bottom and extends from 0 to about 5 kR. (b) Same as (a) except that in this case the image was obtained over the one-second period beginning at 16:02:29 UT on March 26, 1992, and the artificial aurora was superimposed upon a somewhat weaker quiet auroral arc.

Figure 3a

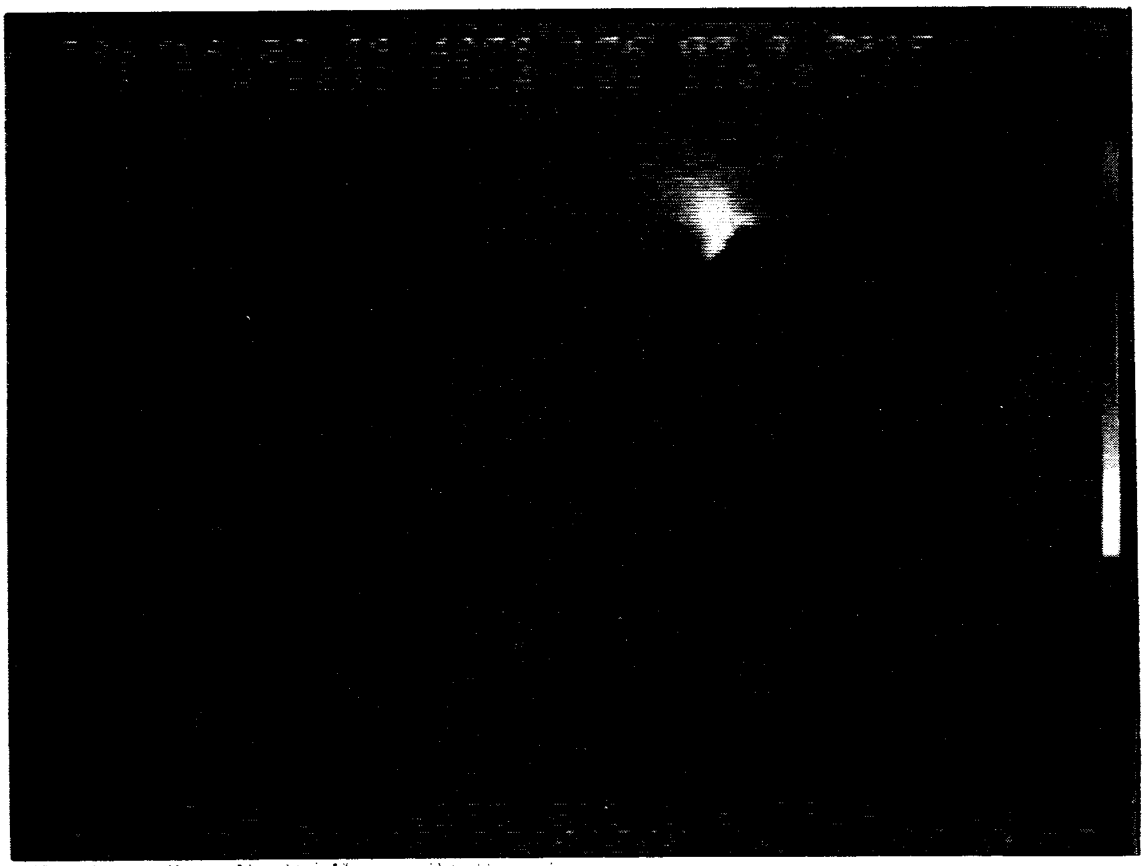


Figure 3b

TIME CONVERSION CHART

UTC	EDT	EST/ CDT	CST/ MDT	MST/ PDT	PST
0000	2000	1900	1800	1700	1600
0100	2100	2000	1900	1800	1700
0200	2200	2100	2000	1900	1800
0300	2300	2200	2100	2000	1900
0400	0000	2300	2200	2100	2000
0500	0100	0000	2300	2200	2100
0600	0200	0100	0000	2300	2200
0700	0300	0200	0100	0000	2300
0800	0400	0300	0200	0100	0000
0900	0500	0400	0300	0200	0100
1000	0600	0500	0400	0300	0200
1100	0700	0600	0500	0400	0300
1200	0800	0700	0600	0500	0400
1300	0900	0800	0700	0600	0500
1400	1000	0900	0800	0700	0600
1500	1100	1000	0900	0800	0700
1600	1200	1100	1000	0900	0800
1700	1300	1200	1100	1000	0900
1800	1400	1300	1200	1100	1000
1900	1500	1400	1300	1200	1100
2000	1600	1500	1400	1300	1200
2100	1700	1600	1500	1400	1300
2200	1800	1700	1600	1500	1400
2300	1900	1800	1700	1600	1500
2400	2000	1900	1800	1700	1600

This chart shows the relationship of UTC to standard and daylight savings time in the contiguous United States. It should be noted that the UT date changes at 2400 / 0000 UT; always several hours head of the new day in North America. Be sure your records account for this by keeping both time and date in UT. 2400 refers to the day that is ending and 0000 refers to the new day. When in doubt about UTC, check with WWV / WWVH on 2.5, 5, 10, 15 and 20 MHz, they announce UT time at the start of every minute.

MODIFYING THE RS-4 VLF RECEIVER FOR LOOP AND REMOTE E-FIELD INPUTS

By
Michael Mideke

This article describes modifications which allow the RS-4 VLF receiver to be operated with loop antennas and external E-field probes. These modifications increase the receiver's utility; they are not fixes for non-functioning receivers. If an existing receiver is modified, it is advisable to begin with a receiver that is working properly. If you are reluctant to dig into a working receiver, consider building a modified version from scratch. The parts are available from Radio Shack and other sources. While the INSPIRE circuit board is convenient, perf-board construction is perfectly acceptable- in fact a completely home-built version with shorter leads to the controls and a metal enclosure may yield superior performance. See **73 Amateur Radio Today**, Dec. 1991 or **A Whistler Hunter's Guide (2nd ed.)** for RS-4 circuit and instructions. The RS-3 circuit as shown in the Oct. 1990 **Lowdown** with modifications described in the April 1991 issue of the same publication is also a candidate for modification. If you are unfamiliar with perf-board construction, see **Science Probe!**, July 1992, P. 87. The technique is illustrated quite clearly. (You can also modify the "BB" whistler receiver shown in that article, but I really recommend starting with the RS-4.) The following references to construction details are based on the INSPIRE kit version but they apply equally well to the other versions. These notes should be considered as guidelines only- parts values are not terribly critical and experimentation should be the name of the game. You can build or modify a receiver to incorporate either or both alternative input options.

LOOPS -

Loops enjoy two immediate advantages over E-field probe antennas. Since they respond to the magnetic (or B-field) component of the electromagnetic wave, they are usable in wooded or enclosed areas where E-field receivers are either completely dead or require quite large antennas. Loops are directional, which is to say they respond more strongly to signals arriving from some directions than others. While a simple single-loop system is practically useless for direction-finding on VLF phenomena, it does provide very effective nulls for reducing power line harmonics or other interference. Depending upon your circumstances, this may allow effective operation somewhat closer to the power lines than is possible with an E-field system. In the particular design shown here, all of the active circuitry follows the lowpass filter. This should substantially reduce the likelihood of overload from nearby Loran C, GWEN and AM Broadcast transmitters. Loops also have their drawbacks. Portability is somewhat compromised, especially for the larger loops required to take full advantage of remote sites. Antenna setup is likely to be a larger chore for loops than with whips or short wires.

The sensitivity of a loop in terms of intercepted signal energy is in proportion to the area enclosed by the loop. The larger the loop's enclosed area, the more signal theoretically available to the receiver. Of course the larger the area enclosed by a loop the greater the minimum wire length required for construction and, for a given wire size, the greater the resistance of the antenna. Wire resistance is one of several factors at work to limit loop performance, so one design objective is to enclose the maximum area with the minimum amount of wire. This is best accomplished with a circular configuration. However, rectangular and triangular configurations are nearly as good, and far more practical for loops more than a few feet across. Considerations of wire resistance and the loop's self-resonant point (which for broadband whistler work should be several times the loop's highest working frequency) dictate that the number of turns be kept to the minimum required to obtain an acceptable impedance match to the receiver input. Except in the case of resonant loops, which are undesirable in our application, adding turns beyond the minimum required to produce an efficient flow of energy into the receiver will not result in increased sensitivity. Each of the loops described below uses about 250 feet of wire; the variables are turns count and area enclosed. The large area loops enjoy a clear advantage over the small area loops.

CONVERTING THE RECEIVER -

We cannot just make a loop and attach it to the FET input circuit of the RS-4. The FET wants to see an input impedance of megohms and any practical loop will look like a short circuit to it. The partial schematic (Fig. 1) illustrates the conversion, which is simply a matter of replacing the FET stage with a suitable transformer. The optional switch (SW) allows selection of either loop or E-field input. Transformer T-1 can be an 8 ohm to 1 K CT transformer identical to that used for L-1.

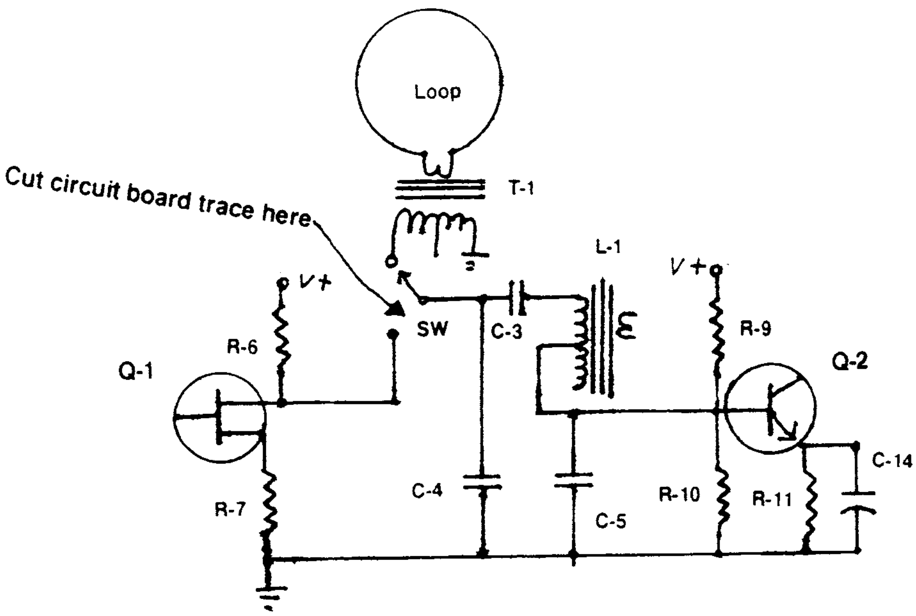


FIGURE 1- Partial schematic of the RS-4, showing conversion to loop input.

RadioShack #273-1380, Mouser 42KM014 or similar are fine. If your transformer has a center-tapped 8 ohm winding, you may do better to attach one leg of the loop to the center tap rather than using the full winding. Experiment!

The first step, assuming you are working with an INSPIRE kit receiver, is to take the RS-4 out of its enclosure and detach the circuit board from the panel. Then you should mount T-1 and any other hardware you wish to add, taking care not to damage components already in place.

T-1 can be attached by soldering its mounting tabs to the inside of the receiver panel, either behind the INSPIRE logo or next to the battery. If you want to preserve the high-impedance input option, you'll need to add a couple of binding posts, banana jacks or some other connector for the loop. Otherwise, disconnect the "ANT" input from the Q-1 circuit, disconnect the "GND" terminal from the circuit board and use these terminals for the loop input. (An earth ground is unnecessary with the loop input.) If you add switch "SW", use a miniature toggle type - it takes only one mounting hole, occupies a minimum of space and will outlast the slide type almost every time. If you run out of room on the panel, additional input connectors and switches can be mounted on the plastic enclosure. Keep leads short and avoid layouts likely to produce feedback.

One modification of the circuit board is necessary. Cut the board trace between C-3 and the junction of R-6 with the Drain of Q-1. You can use a Dremel Tool, X-Acto knife or pocket knife for this operation. If solder has built up heavily on the trace, begin by drawing it off with a hot soldering iron or a solder-sucker. If you are using a knife, take your time and carve a cut at least 1/16" wide through the foil, working from both the Q-1 and C-3 sides, cutting away from the foil you want to preserve to avoid any chance of peeling away needed foil.

C-3 now goes to the center terminal of switch SW and the R-6 / Drain junction is connected to one of the other two switch terminals. Wires for these connections can be soldered directly to the appropriate points on the foil. Use the full high impedance winding of T-1, connecting one side to the ground plane (V-), the other to the remaining terminal of switch SW. Connect the transformer's low impedance winding to the input connectors, re-mount the circuit board and the conversion is complete.

The RS-4 (particularly the kit version) is somewhat microphonic. It tends to produce noise in response to mechanical vibration. The loop conversion seems to enhance this problem. As a problem, it is minor as long as you secure the receiver in place (duct tape is helpful) and avoid unnecessary handling while recording.

BUILDING LOOPS -

As indicated above, large loops provide more sensitivity than small ones. The size loop you need is pretty well dictated by how far you are willing to go from power lines to use it. However, the loops I'm about to describe are easy to make; there is no need to stop at one. I suggest a small one to test the receiver and to get a feel for how loops work, then a larger antenna for serious use in the field. The loops described here were all built from materials that happened to be at hand. Construction and testing of all three occupied only a few hours. Minimal effort was devoted to optimization, but all of the antennas worked. Refinement can be developed "by the book" or through cut-and-try; the basic point for now is that effective loops are pretty easy to make. The parameters are quite forgiving.

LOOP #1 -

The first test loop was 30 inches square, mounted on a cross shaped framework built from wooden "trim" stock, 3/4" X 1 1/2". Small nails were driven at the extremities (at right angles to the plane of the frame) to hold the windings. The frame was wound with 25 turns of 24GA vinyl insulated wire. About 6 feet of wire was left in excess, twisted to form a "twisted pair" for connection to the receiver. Total length of wire = 262 feet. Note that the transmission line from loop to receiver should not be more than about 6 feet, and even then it might be well to use heavier conductors- say 14GA "zip cord". This loop hears weak morning sferics and will certainly hear strong to medium whistlers. It is noticeably better than a 19" 40 turn loop and also a good bit hotter than many of the INSPIRE results recorded during STS 45. However, receiver noise dominates the output. In most applications the RS-4 needs a bigger antenna to achieve an acceptable signal-to-noise ratio.

The crossed-member wooden frame is useful for loops up to about 2 or 2.5 meters. Beyond about 1.5 meters, portability is enhanced by making the central frame connection with a bolt that allows the frame to be dismantled or folded shut. Steel "L" brackets secured to the ends of the frame arms can be used to support the windings. Wind the loop as described above, but secure the windings to the brackets with string ties. For transport, remove the wire and bundle it up, collapse the frame and you are ready to go.

LOOP #2 -

The second loop is a triangle 40 feet in circumference, consisting of 7 turns of 22GA stranded, insulated wire. The triangle's horizontal base is 15 feet long and the feedpoint is at the center of the base. The remaining legs are both 12.5 feet. This is a "soft" loop, having no frame. It is very easily wound by driving pegs into the ground to mark the 3 corners and the feedpoint. Start at the feedpoint, leaving a few feet of excess wire for connection to the receiver. Walk around outside of the triangle defined by the pegs, uncoiling wire as you go until the desired number of turns is achieved. When winding is complete, wrap the resulting wire bundle with electrical tape every couple of feet. Wrap the corners and the feedpoint with more tape for extra protection. Attach a loop of cord to the apex for support. You can also do this for the lower corners, but their actual location may have to be shifted to accommodate available supports. To use the soft loop, pull the apex up a tree or pole, secure the lower corners to trees, poles or pegs in the ground. It is a good idea to get the loop base a couple feet off the ground and if it can be supported above head level, so much the better. However this is more a matter of physical convenience than electrical necessity- elevating loops does not lead to the dramatic increase in signal level experienced with small E-field probes when their height is increased. This loop was 8 to 10 dB more sensitive than #1. It hears whistlers down to "medium weak" but at 4 miles from the power lines it produces no trace of AC hum in the RS-4, so it isn't really good enough for the site. However, at 3/4 to 1.5 miles from power lines it should be just about right. Rotate the loop (a couple of helpers are really useful for this!) until power line hum is at a minimum. Loops of 3 and 10 turns, otherwise identical, proved somewhat less sensitive than the 7 turn version.

LOOP #3 -

This is a three-turn 77 foot circumference loop with a 29 foot base. I didn't have enough 22GA wire to make it, so I used some "twisted pair", paralleling its two strands of 26GA stranded wire. While doubtless far from optimum, this loop was about +6 dB with respect to #2- almost good enough to hear power line hum at my site. It will definitely hear weak whistlers and emissions. Ratio of signal to circuit noise is superior to that obtained with a two meter whip from an optimum site. Results deteriorated somewhat when I tried using just one strand of the pair and when I connected the strands in series to form a 6 turn loop. Probably 4 or 5 turns of heavier gauge wire would be somewhat better, but this works awfully well and it rolls into a small, highly portable bundle.

TRANSMISSION LINES -

If the loop is to be more than a few feet from the receiver, transformer T-1 should be placed at the loop as illustrated in Figure 2 (left). You can use the transformer output to feed 50 feet or so of twisted pair or TV twinlead, driving a "1:1 Isolation Transformer" of 600 to 1,000 ohms at the RS-4. RadioShack's #273-1374 will do the job. The other steps in the conversion remain as above. A better solution, and one that is essential for longer runs, is to perform at least part of the system amplification at the antenna. In the case of the RS-4, the easiest thinging to do is to just put the whole receiver at the antenna and run a transmission line. This option is shown on the right side of Figure 2. A small box with a couple of jacks and switches will take care of managing the VLF signal, monitor amplifier, time and local voice announcements, etc. at the recorder end. With an arrangement of this type, the receiver is likely to be left on for long periods, so a larger battery supply is in order. The RS-4 is happy with supply voltages up to 14V, so lantern batteries or large NiCad packs are a viable replacement for the 9V transistor battery. NiCads or a Gel type lead-acid battery in conjunction with a small (~50 ma) solar panel should support a permanent or semi-permanent installation.

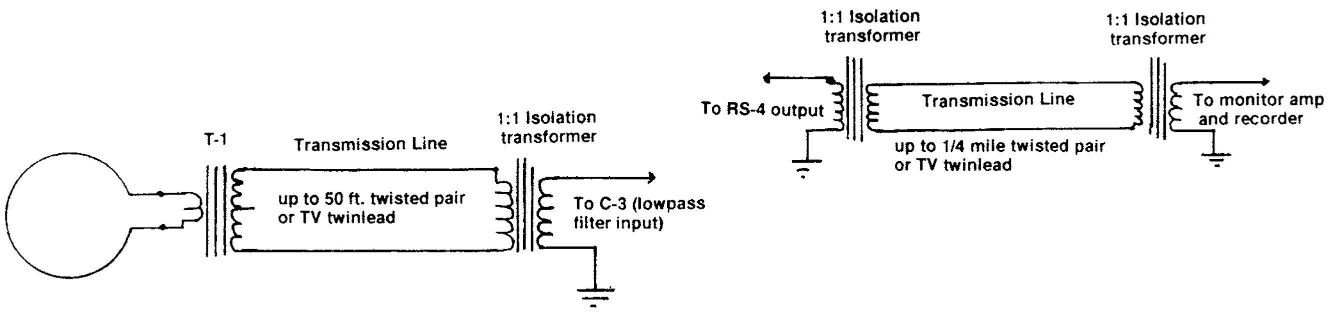


FIGURE 2- Two methods for separating the antenna from the operating position.

WIRE -

Small loops can be wound with solid wire but large loops, especially if they are intended for portable service, should be made from stranded wire. Radio Shack speaker wire looks like a reasonable source of loop material. #278-1385 gives you 100 feet of 22GA double strand for $5.49. The strands can be series connected for an effective 200 feet. Two rolls should do the job with wire to spare. **Fair Radio Sales**, Box 1105, Lima, Ohio 45802 has 16GA stranded vinyl covered hookup wire at $5 per 100 feet. Also other wire items in their large, free catalog. Write for it.

REMOTE E-FIELD PROBE -

If you've worked with the RS-4, WR-3 or a similar receiver, you've doubtless discovered that the antenna is very sensitive to all sorts of nearby activity, even things that we don't usually think of as electrical events. Also, the "in the clear" locations required by small probe antennas are often highly uncomfortable places to set up camp. These are strong arguments for separating the antenna from the control position. What is needed is an "active antenna" that combines pre-amplifier and antenna functions a good length of coax away from the rest of the equipment. The RS-4 is readily adaptable to this configuration. The partial schematic of Figure 4 shows how it is done.

The 680 ohm resistor (identical to R-6) and C-3 provide a decoupling network that allows power to be passed on the same line that delivers signal to the lowpass filter. Since the coax braid effectively becomes a counterpoise for the probe antenna, earth ground requirements may be reduced or eliminated when this arrangement is used. The preamp unit can be identical to that of the original RS-4 circuit- the version shown here is somewhat more sensitive. Zener diodes D-1 and D-2 should be 5.1V 0.4 watt units. They provide the FET with some protection against burnout from static electricity buildup and nearby RF sources such as radio transmitters or lightning discharges within a few miles of the antenna. If the diodes are not used, substitute a capacitor of 27 to 60 pF. This won't protect the FET but it will reduce the incidence of overloading by high frequency signals. A 1 megohm potentiometer can be substituted for the 3 series antenna resistors and the switch shown in the preamplifier schematic. The operating guideline here is to insert series resistance until overloading of the receiver and distortion in recordings are no longer apparent. The required setting may vary with time of day and from site to site.

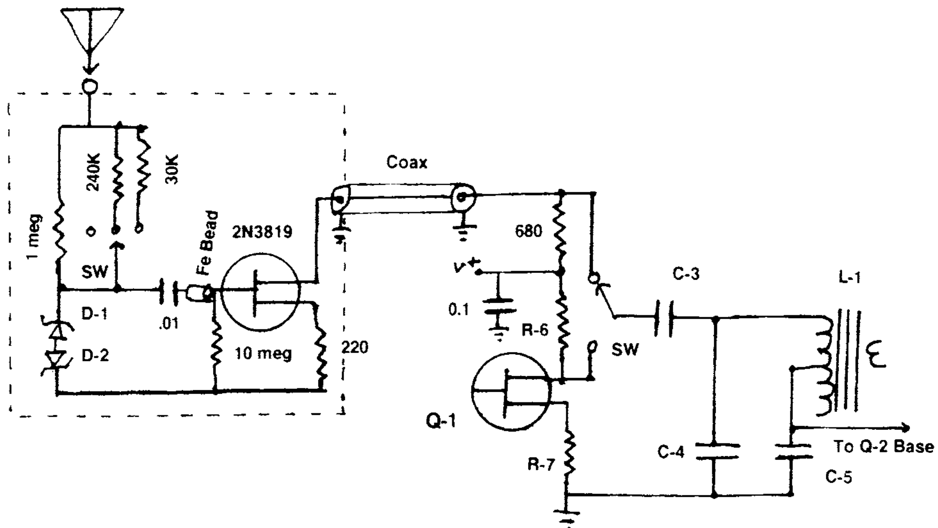


FIGURE 3- Partial schematic showing the RS-4 adapted for use with a remote active antenna.

The preamp unit should be built in a small metal enclosure. I recommend BNC connectors for receiver and antenna unit but any other coaxial connector can be used. You can run at least 100 feet of RG-58 or RG-59 coax with this arrangement- enough to get the antenna high and clear and out of the way. For longer runs, use the approach shown in right side of Figure 2 . Since the coax has DC voltage on it, it will act as an electret microphone. Mechanical disturbances of the coaxial cable are likely to produce noise in the receiver. With care, this usually won't be a big problem. However, a better arrangement would be to provide the preamp with its own battery, preferably located at the preamp. If this is done, the 680 ohm resistor, along with coupling and bypass capacitors should be incorporated in the remote unit. Stronger preamps, such as the GW Forgey MK-III (**The Lowdown**, May, 1992, Page 32.)can be substituted if front-end overload proves troublesome.

Monitoring Output of the INSPIRE RS-4

Numerous Project INSPIRE logs were left blank except for a note indicating that it was impossible to monitor while recording. Leaving aside my big question : "So why didn't you listen to the tape afterwards?", the solution is simple. Just add a jack to the panel, connecting it via an 0.1 microfarad capacitor to JP-9. The new jack will deliver receiver output (but not time signal or microphone output) to an external monitor amplifier such as Radio Shack #277-1008. This arrangement allows you to monitor whether or not a recorder is running. It saves strain on the recorder batteries and encourages you to stay in touch with the performance of your VLF receiving system. If the monitor produces feedback, check and improve the ground system and make sure that all wires and cables carrying high level audio are well away from the antenna. As a last resort, turn the monitor level down well below the point where feedback occurs. I say this is a last resort because the cause of the feedback is still there, and probably sufficient feedback to create distorted recordings as well. Do not use the monitor amplifier to drive the recorder's microphone input. Noisy, distorted recordings are the most likely result. If that kind of a "boost" is needed it probably means something is wrong with the receiver or the antenna is inadequate for the site.

A note on Making Clean VLF Recordings

Remember that unless your recorder has a third head so that you can hear what has actually gone on tape, the "monitor" feature of the recorder tells you almost nothing about what's happening to the tape. But no matter what kind of recorder you are using, the object is to make recordings that accurately reproduce the receiver's output. The third head is a great convenience for making adjustments to the receiving system, but you can get along without it by alternately listening to the monitor and bits of just-recorded tape. If the sferics are fuzzier on the recording than in the monitor, or if extraneous Omega tones appear on the tape, reduce the receiver's high frequency response. Try adding .005 microfarad in parallel with C-9. If that helps, but not enough, try .01. Or increase the antenna series resistor. If you have plenty of signal from the receiver, you can try reducing the output level. If the recording is substantially weaker and noisier than the monitor's output, something may be wrong with the recorder or the connection to the recorder.

BARKHAUSEN EXAMINES WHISTLERS AND CRACKLING DIPOLES
By: Jim Ericson

Recently I received from Michael Mideke a copy of some original German articles in a physics journal written in 1919 by H. Barkhausen on the subject of whistlers. I believe that Barkhausen was the first to write about this phenomenon, and probably was the first to begin putting together pieces of the puzzle. It wasn't until many years later that scientists began to understand the role played by the earth's magnetic field on the propagation of whistlers.

The following (with some editorial license) is my own translation. It may not be completely accurate, but it's close enough to give us a good feeling for what Barkhausen knew (and didn't know) at the time:

WHISTLES FROM THE EARTH
by: H. Barkhausen from: Physik.Zeitschr. XX, 1919

During the war, amplifiers were used by both sides on the front to overhear telephone communications from the enemy. As a result of poor insulation, there were induction effects that caused stray earth currents far from the vicinity of the telephone cables. High amplification was able to make these extremely weak signals hearable. The monitoring circuit is shown in Figure 4. The monitoring grounds were usually about 100 m apart, and simply guided the signals to the amplifier and earphone.

Sometimes a peculiar whistling tone was heard. On the front when they heard the tones the men said, "The bombs are flying!"

The characteristic of the tones was something that sounded like "PIOU". My observations are that the tones are amplitude-stable, but very rapidly they change frequency as shown in Figure 5, beginning with the highest tone and decaying to the lowest hearable tone. The tones seem especially pronounced at about 1000 cycles. The entire phenomenon lasts a full second. On some days these whistles were so loud and frequent that it was useless to monitor for telephone communications. This phenomenon certainly depends on some meteorological influence. Crackles and burbles were especially prevalent during normal atmospheric disturbances on mornings in May and June.

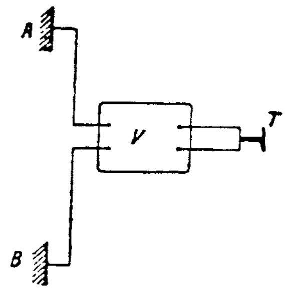


Fig. 4.

A, B = earth electrodes
T = telephone handset
V = vacuum tube amplifier

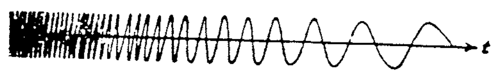


Fig. 5.

The 'earth electrodes' sometimes also picked up noise, but this can hardly be the cause of the whistles.

I have myself in the laboratory futile troubles to make a connection with direct discharges and such whistles.

Where for certain in the earth and in the sea these distinct weak signals originate is unexplainable. Perhaps with this apparatus, wider intelligence can be brought to bear to clarify and contribute.

Dresden, Institute for Weak Current Technology

(entered 17 May, 1919)

Barkhausen is probably best known for his discovery of a magnetic phenomenon that was later dubbed "The Barkhausen Effect." If a rod of ferromagnetic material is surrounded by a pickup coil connected to a high-gain audio amplifier, a peculiar 'crackling' hiss is heard when a magnet is moved in the vicinity of the rod. In 1919, Barkhausen correctly deduced from his experiments that the noise had to do with the realignment of all the little magnetic dipoles in the iron as they became influenced by the magnetic field.

Barkhausen published a paper on the subject in the same journal containing his whistler piece. So I translated the dipole noise piece too.

In Barkhausen's words, *"Iron gives a sound or noise by changing the polarization of its magnetic polarity. By steadily varying the magnetomotive strength of the molecular magnets, they 'flip' into new positions and produce in a surrounding coil impulses which can be detected as noise in an earphone."*

Well, I got interested in the darned thing, and finally broke down and replicated his experiment.

From my junkbox I resurrected a small (1/2-inch diameter) coil from an old tunable inductor. I connected the coil directly to the high impedance microphone input of my Marantz tape recorder. Through the coil I placed a short piece of a straightened paper clip (I also tried nails and other iron objects). Then, while listening on headphones, I moved a refrigerator magnet around in the vicinity of the coil. My goodness! It works! Very odd noise and crackles as the little dipoles flop around inside the iron. Lots of hysteresis effects can be noted also. In addition, I observed microphonic effects when either the magnet or the iron core were tapped or jiggled.

From the two Barkhausen pieces I translated, it was clear that here was an old fashioned experimenter of the first calibre! There was a complete absence of math, but lots of cut-and-try, and a good deal of what turned out to be very accurate deduction about what was going on. Herr Barkhausen certainly exemplified the spirit of experimenters!

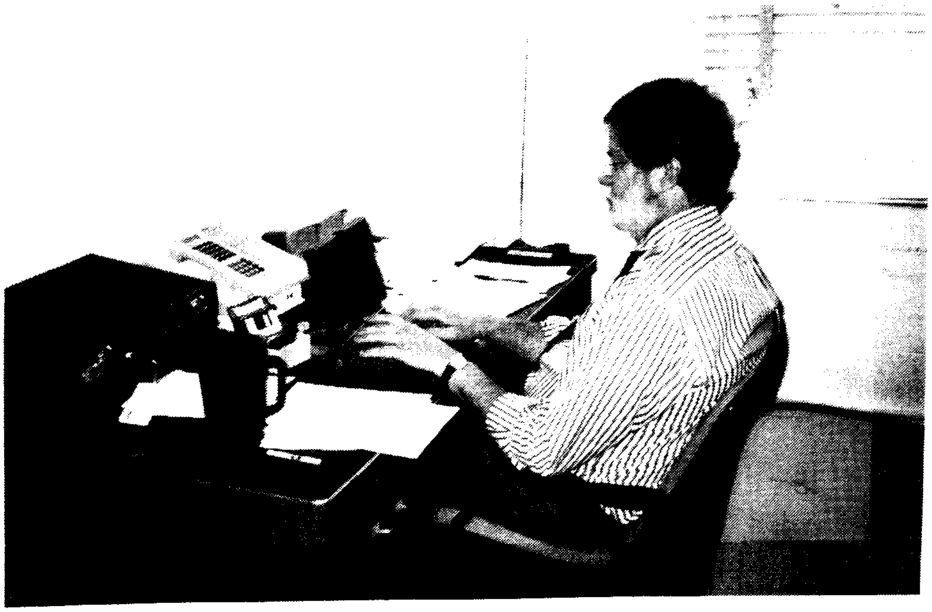
Jim Ericson 226 Charles Street Sunnyvale, CA 94086

Barb Ranson of Sebeka, MN, organized a week of special activities for the sixth graders at Sebeka School. Preparation for the week's activities included participation in INSPIRE.

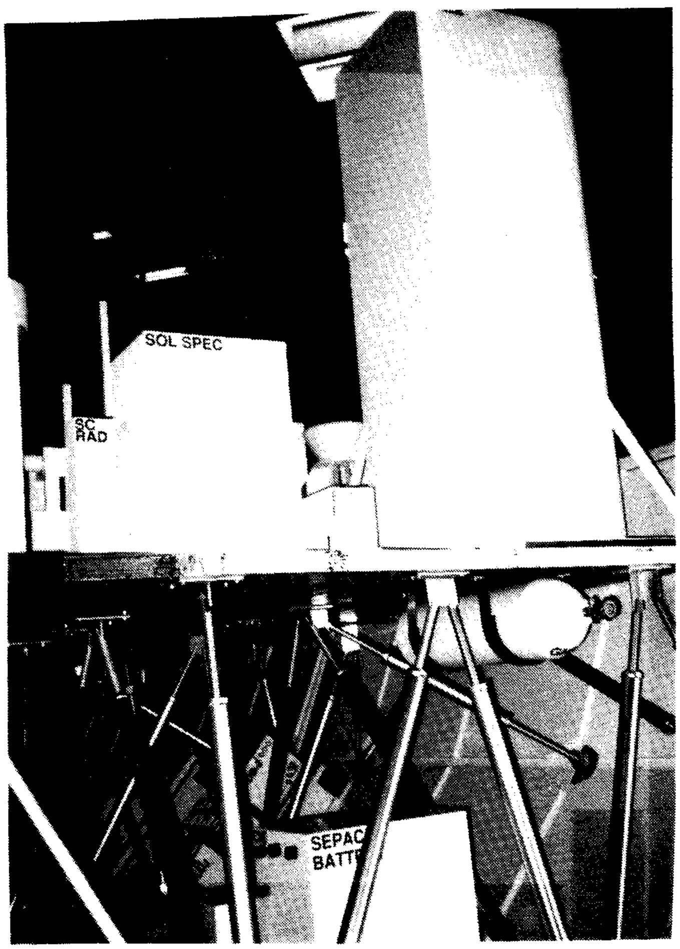
Ashlee checks out the grounds. Thanks to the gophers, there was some unfrozen ground for setting ground rods. The rods are about 1' to 1 1/2' of copper pipe. Monday 6:15 AM 10 degrees F
In the background: Carrie and Chris

A Chaffey High School post-mission Dawn patrol. Left to right: Vassil Apostolov, Bonar Chiu, Paul Verbansky, Bill Pine, Mike Torrez. Photographer: Efert Weenas. An interesting international collection: Vass was born in Bulgaria and has been in the U.S. for 4 year; Bonar was born in the U.S., his parents came from China; Paul was born in Germany, has been in the U.S. for 6 years and speaks 6 languages; Bill is 5th generation Californian; Mike is third generation Mexican-American; Efert was born in Indonesia and has been in the U.S. for three years. All are A students (except Bill!). This type of ethnic diversity is typical of Chaffey High School; this diversity also makes my job challenging and enjoyable.

Russ Steele acted as advisor for the Seven Hills INSPIRE Team from Seven Hills Middle School in California. Top photo shows the team in the field. Bottom photo was taken during construction of the receiver. In the bottom photo: Russ Steele, Scott Wiederhold, Matt Hieb and Cait Steele.



Bill Taylor works in the INSPIRE office at the POCC (Payload Operations Command Center) in Huntsville, AL. The office was originally supposed to be the base of operations for INSPIRE, but it turned out that we had to be in the SEPAC SOA (Science Operating Area) to stay on top of things. The office then became a quiet getaway location to catch up on INSPIRE business. Bill is using his Mac Powerbook and a modem hookup to update bulletin boards.



A full-scale model of the pallet was on display at the Space Museum. Visible near the bottom of the photo is the SEPAC battery and just to the left of that is the HVC (High Voltage Converter), the home of the infamous fuse. Near the center of the photo (between the large boxlike instruments) you can see the EBA (Electron Beam Accelerator).

Fall '92 Operations at Chaffey High School

by Bill Pine

Since no coordinated formal INSPIRE operations are scheduled for the fall of 1992, I thought I would outline the program that we run at Chaffey High School each year.

The program here consists of four phases:

1. Receiver assembly.
2. On campus drill.
3. Evening field observations ("sunset runs").
4. Early morning observations ("dawn patrol")

The idea of the phases is to introduce the students gradually and sequentially to the more demanding aspects of natural radio observations (like getting up at 5:00 AM!).

Receiver assembly is conducted after school in one hour time segments. Four or five students participate each time. Students sign up for the sessions that they want to attend. Once a student attends a session, all of the rest of the class gets a chance to sign up before that person's turn comes up again. This way everyone who wishes to be involved is able to do so.

The assembly of the RS-4 receiver takes about 6-9 hours when done this way. The more students who are involved, the longer it takes. The stages of the assembly are:

- Hour 1: Reading resistor codes, identifying capacitors, soldering technique, practice soldering on surplus components. Each student attaches at least one component to the board.
- Hour 2: Attaching wires to switches, attaching wires to jacks. Each session wires one complete switch and one jack.
- Hour 3: Identifying semiconductor components, attaching the IC socket to the board, pinout configurations, attaching the semiconductors to the board.
- Hour 4: Attaching the switch and jack wires to the board, circuit checkout and testing.

The reason that it takes more than the four hours listed above is that each of the sessions may be repeated three or four times depending on how many students want to participate. My experience has shown that to involve 4-6 students, assembly takes about 6 hours; to involve 12-15 students, assembly takes about 9 hours. This year I have over 30 students who have expressed interest, so I do not know how long the assembly will take. We will be constructing 2 receivers and modifying 2 others for loop antennas. I'll let you know how it goes.

The other phases of the preparation all involve the same features:

1. Setting up the receivers and connecting the ground wires and recorders.
2. Setting receiver and recorder levels.
3. WWV time marks.
4. Practice logging.

"On campus drill" consists of setting up the equipment on the south quad just outside the door of my classroom. We set up three receivers with recorders and clipboards for logging. The advantages of this arrangement are: no transportation off campus is involved, the entire class can be involved (by taking turns), and the activity occurs during the hour after school. The disadvantage is that the listening takes place in a very noisy environment, so long term listening and recording is not done. We set up and take down the equipment enough times so that each pair of students has gone through the process at least once. Only a couple of these sessions are required.

"Sunset runs" consist of travelling to our listening site before sunset, setting up the equipment, listening from about 20 minutes before to about 20 minutes after sunset. At some point during the latter half of the listening time we record a session using WWV for time marks and recording for about 7 minutes. If the natural radio activity level is high, we may record for longer periods. We log the entire time we are listening and note the parts of the log that are recorded on tape. On the way back to campus we listen to the tapes on the car stereo and refer to the logs.

The advantages of the sunset runs are: actual natural radio can be heard in an elecromagnetically quiet site, and field conditions are identical to those encountered in SEPAC-style operations. The disadvantages are: off-campus travel is involved, and the number of students participating is limited. I have a Chevy Astro van which can carry 8 passengers (including the driver). We take 6 or 7 students each trip. Students pair up and take turns with the three receivers and the seventh acts as timekeeper with WWV. All jobs are rotated during the session. On a couple of occasions I have taken more than this number (with the help of my science colleagues as drivers), but I have found that too many people make the experience less valuable for everyone. (Translation: teenagers tend to just screw around if they are not kept busy!)

The time breakdown for a sunset run is:

time to reach the site:	35 minutes
setup time:	15 minutes
listening/logging:	40 minutes
breakdown equipment:	10 minutes
time to return to campus:	20 minutes
TOTAL TIME:	2 HOURS

"Dawn patrols" are similar to sunset runs except that the recording is for 7 minutes on the half hour before sunrise and the half hour after sunrise. For example, on the last two weekends in October the sun rises between 6:30 and 7:00 AM. So we record for 7 minutes starting at 6:30 AM and again for 7 minutes at 7:00 AM. We listen and log for the entire time we are on the site and if the activity level is high we will record more than just the two 7 minute sessions.

The advantage of sunrise monitoring is that that is the best time of day for whistler activity. The disadvantage is the obvious one of the early morning hours involved. I require that each student participate in at least one on-campus drill and one sunset run prior to going on a dawn patrol. At dawn you have to be able to set up in the dark and cold (our site is at 6000 feet elevation and is cool to cold every morning), and I have found that this is a poor environment for first-time participants.

Our fall operations end with the observations at dawn on Saturday and Sunday of the last two weekends in October. I choose those two weekends because after the change to Pacific Standard Time (which occurs on the last Sunday in October) dawn comes one hour earlier - a much less convenient time for both me and my students!

Over the years I have discovered (often the hard way) some "tricks of the trade" for this type of student activities:

1. Points are awarded for participation. This type of activity is part of the students' lab grade which is 25% of their overall grade. I require that each student earn 5 points per semester outside of the classroom. All natural radio activities qualify for this. Points are awarded at the rate of one point per hour of participation. Dawn patrols are worth 3 points (for 2 hours + one bonus point) for obvious reasons. If a student chooses to be involved in the natural radio activities and participates in all aspects he will earn more than the required 5 points. The extra points go toward raising the student's grade.

I will say that I resisted the concept of giving points for something that I thought the students should want to do because it was interesting, fun and worthwhile. Since I started giving points for participation, the level of involvement increased dramatically. Ironically, the most involved students are the ones who need the points the least. The number of points available is not a significant fraction of the 500 points which compose a semester grade. If a student is an "A" student, they are motiviated by points whether they need them or not; a "B" or "C" student can see the benefit of participation for holding or raising their grade.

In addition to the natural radio activities, students may earn points outside of the classroom by participating in the Physics Olympics, AAPT competitive examination, Physics Day at Six Flags Magic Mountain and other activities that may come up.

2. All activities run on schedule. High school physics students are very busy and their time should be respected. When we schedule a sunset run or dawn patrol, the departure time is set and the van leaves at that time. No waiting for any latecomers and no excuses for being late.

3. A signup sheet is used for each activity. Students are not to sign up until they have checked their schedules and they can commit to being there on time. Any student who does not keep the commitment made on the signup sheet loses the number of points they would have earned by attending. I learned this one about 4 years ago when I was sitting by myself at 5:30 AM in the parking lot at school and NONE out of six students showed up. The negative point feature put a quick end to that!

4. Murphy's Law might have been written for natural radio research. Be sure to carry an extra battery for each battery you have in use. For our trips, I check out all of the equipment prior to a sunset run or dawn patrol and then I carry the following extra batteries:

3 receivers:	3 9V
4 recorders:	8 AA
4 flashlights:	8 D

I also carry two complete sets of tools:

screwdrivers (blade and phillips)
nut driver
wrie cutters
hammer and 4 lb. sledge

5. Remember, one of the main goals is to have fun! If you do not make it fun, you will soon be operating a one person team. These activities give you a wonderful opportunity to get to know your students in a way that you cannot in the classroom.

Be sure to write up your fall activities and submit the reports to the JOURNAL. Let us know how it went!

Student Participation in INSPIRE

(Editor's note: After the STS-45 mission, I was asked by my principal to write a report for his principal's newsletter about the INSPIRE project. It seemed to me that it would be more appropriate for students to report on their involvement and he agreed. The following were submitted by Chaffey High School physics students in June of 1992. As a note, the references to the "socks incident" and to "forgotten shoes" refer to one student who overslept one morning and in his rush to get to school forgot to put on his shoes! He arrived too late for that trip, which is just as well since the temperature up on the mountain was about 35 degrees. Anyway, he was called "Socks" for the rest of the year. He lost two points by missing the van that morning, but he earned more than 30 points all together with his participation in INSPIRE.

As a final note, when people ask me why I teach or why I get involved in activities such as INSPIRE, I think I could just hand them these essays....)

INSPIRE ... Students' Perspective

by Aketa Narang

As many people know, the Physics class on Chaffey's campus has been involved with a nationwide science project known as Interactive NASA Space Physics Ionosphere Radio Experiments, (INSPIRE). The students in our physics class worked many after school hours in preparation for the project which included taking trips to the mountains at 4:00 AM (yes, that's four in the morning on Saturdays!) and folding, stuffing, sealing and sending 9,000 letters (No, it's not a mistake in the # of zeroes, it's actually nine thousand letters).

It may be difficult for some to understand why the students in our Physics class and Mr. Pine worked so diligently and enthusiastically with this project. It wasn't because we had to do it for a grade, or that we wanted recognition for our work. The plain reason is that science is fun!

As I look back on our efforts, I know that what I enjoyed most was working with my classmates and Mr. Pine. One really must love the people one works with if he is willing to spend early Saturday mornings working with them. I know I speak for myself and for the other kids in my class when I say that we will never forget the project INSPIRE or those morning runs up the mountains in the Pine-mobile!

CHAFFEY PHYSICS STUDENTS PROUD TO BE A PART OF INSPIRE

by Andy Stewart, Class of 1992

The words from which we take INSPIRE, "Interactive NASA space Physics Ionosphere Radio Experiments", may seem a bit bureaucratic, but to the students of Mr. Pine's physics class it was more than just an acronym. INSPIRE, as its name alludes to, was interactive, giving high schools of 500 or more students across the United States a chance to get involved hands-on with a scientific endeavor.

The Atlas project's objective is to study the distortion on radio waves caused by the upper atmosphere. Although textbooks present a polished, finished explanation of nature, INSPIRE held out the unknown and unexplained. By establishing a broad base of receivers across the country, it was hoped that a "foot-print", describing who heard and didn't hear a signal sent from the shuttle, could provide insight into the earth's upper atmosphere.

In practical terms, INSPIRE meant: staying after school to send out mailings and kits ("more bubble rap"), and going up in the local mountains to practice gathering data (the "socks incident"). Although the transmitter on the space shuttle broke down before a majority of performances, we, the physics students of Chaffey, were proud to have an active role at the base of operations for a nationwide project.

The Preparation Mountain Trips

by Paul Verbansky

Hours were spent in freezing cold and twenty below.
Rain did not stop us nor a strong wind's blow.
Up on the mountain we stood many of evening,
And in early hours before the day was beginning.

Shoes were forgotten on trips up the hill,
Where with donuts and hot chocolate we got our fill.
We sat on the mountain in beach chairs too small,
To hold one man with notepad, recorder, tapes and all.

We sat listening to whistlers, pops and then a crack;
Sounds made by lightning as they bounced here and back.
Each trip we spent preparing ourselves in every way,
For "when the shuttle will come over on that special day!"
Yet NASA goofed up and there we were,
With the shuttle above us in space somewhere.
The "gun" was set and ready to shoot,
But then it malfunctioned without even a toot.

Yet memories were made in more than one way,
From the time we stuffed envelopes to that special day;
Special, since we were prepared and wholeheartedly tried.
Hey, it's not our fault NASA had a bad flight!