

SPELEONICS 26

COMMUNICATIONS AND ELECTRONICS SECTION OF THE NATIONAL SPELEOLOGICAL SOCIETY

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Editor: Paul R. Jorgenson KE7HR
NSS 39382 FE ke7hr@cox.net

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Contributions of articles for publication is **highly encouraged**.

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Send articles for publication to:

Paul R. Jorgenson KE7HR

ke7hr@cox.net

A Radio Location Device for Cavers

Daniel Chailloux

[edited from a French Translation]

The radiolocation device assists in determining from surface, the position and the depth at which a transmitting beacon is placed under ground, in a cave, using a specialized radio receiver.

This device is a complement to cave surveying. It allows very precisely:

To fix a cave survey compared to the external relief

To know co-ordinates GPS of points characteristic of the cavity

To establish on the surface reference marks corresponding to particular topographic stations of the cave (large rooms, crossroads of galleries, siphon...) for the optimum use of a communication system by the ground (Nicola system for example)

To carry out a drilling in order to communicate with a team in difficulty in the cave

To know the depth of a possible drilling to open a new entry or to carry out water pumping to feed a village.

Principle

Figure 1 shows how the lines of magnetic field produced by an electromagnetic reel placed in the environment of an underground cavity are propagated. The point of emergence "O" of the vertical line of field located at the balance of the beacon is called "Point Zero" or "Zero Ground - G.Z." among Anglo-Saxons. It is this point, which one will try to determine or radio-to locate more exactly.

The transmitting beacon must be laid out in the cave in the vertical position. For that, it is easy to suspend it from the ceiling, to hang it from a tripod in the center of the room (or the siphon) to be located, or to "pose it" on the floor and fix it vertically using a spirit level.

The topography of the cave is inferred beforehand on the geographical chart. The surface team moves in the area expected to be near "ground zero" of the transmitting beacon. When the characteristic signal of the transmitter is perceived in the earphones, the search for "ground zero" starts. The localization by a method of triangulation will take between 15 and 30 minutes!

The receiving framework constitutes the "reel of reception", which will collect the emitted signal. The copper wire is rolled up on a square structure of 58 X 58 cm. Electronics are protected in a small case fixed on the framework itself. A headphone allows listening to the low

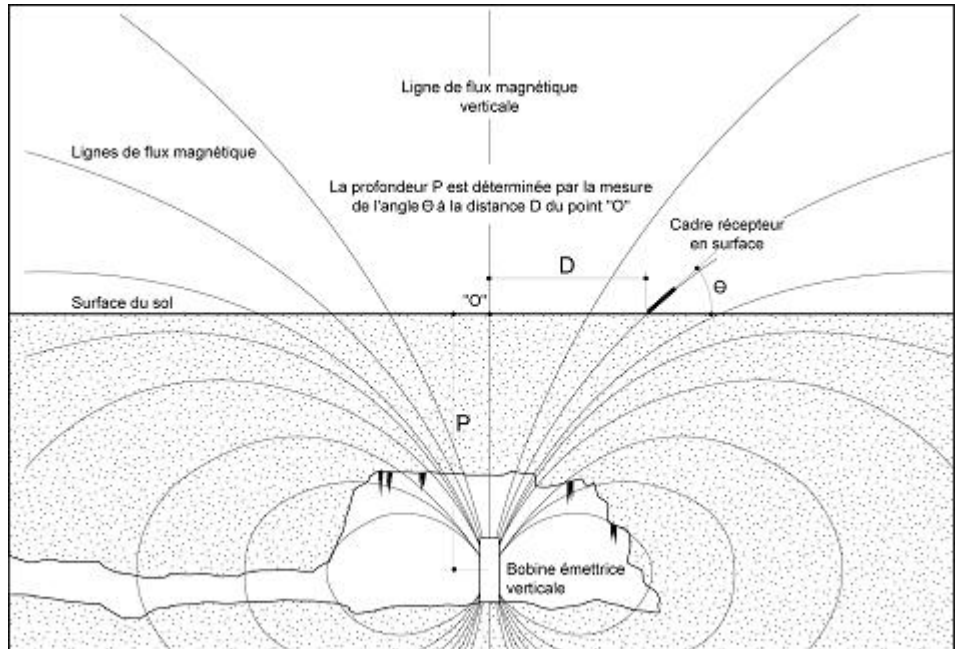


Figure 1

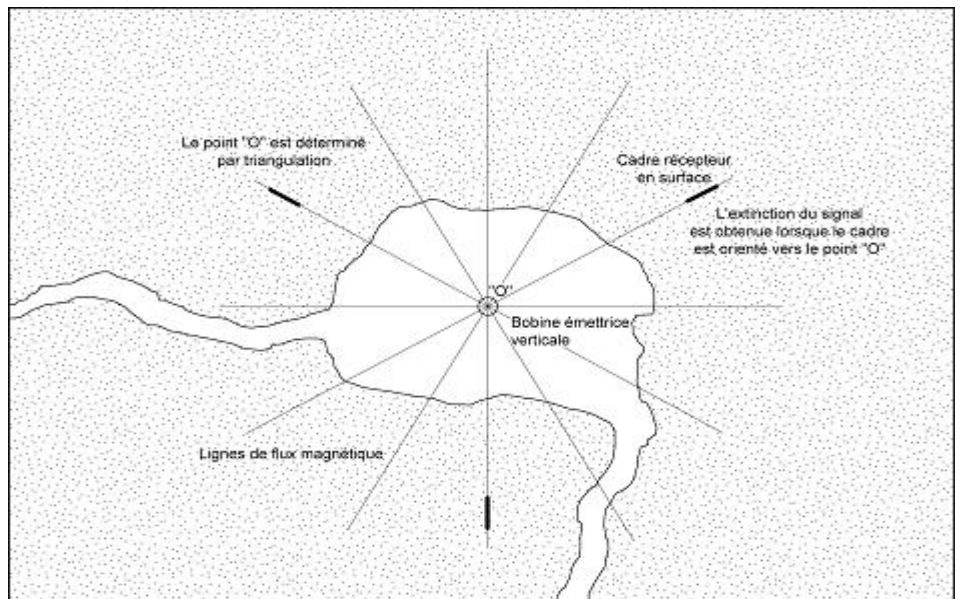


Figure 2

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frequency signal. An adjustment of selectivity and sound volume makes it possible to adjust the received signal according to the characteristics of the ground. The framework antenna is very directive. The signal varies in intensity according to its orientation to the transmitted field.

Determination of "Ground Zero"

1. Move to the area estimated to be near "ground zero" above the transmitting beacon. As soon as the signal is perceived, move the framework antenna to seek a null signal (figure 3). The signal is null all along the field line. A cord strung between two stakes (P1 and P2) will allow visualization of the field line.

2. Move out of this line by ten meters and renew the operation. Seek a null signal again and tighten a new cord between the stakes P3 and P4. The two cords cross at a point that is theoretically with the balance of the transmitting beacon or at "ground zero".

3. A third nulling operation, starting from another point, is done and a cord tightened between stakes P5 and P6.

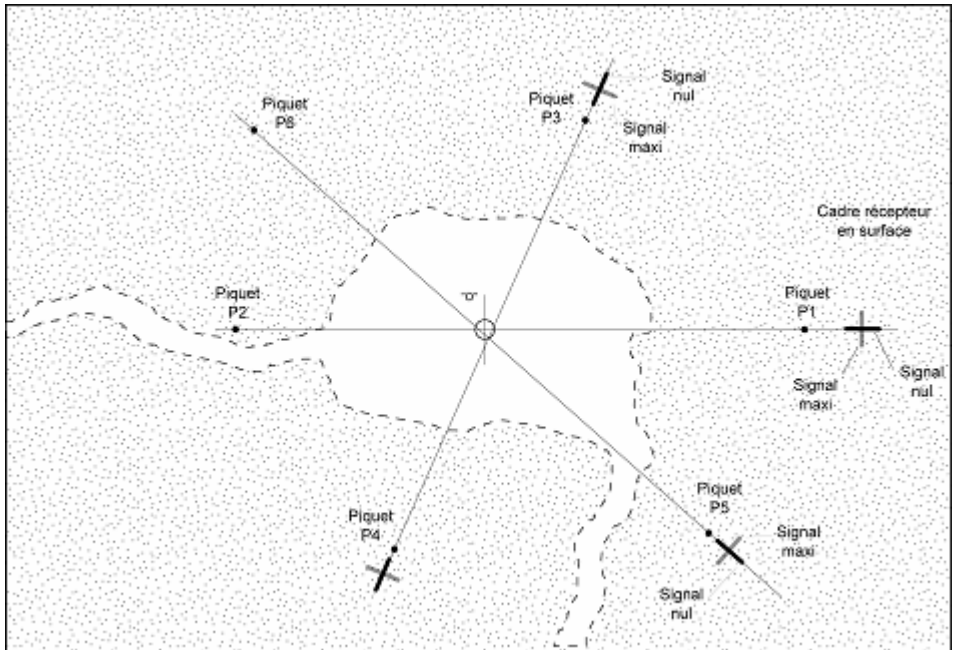


Figure 3

The three cords should cross at the point "O". In reality, they form a triangular zone that is called the "triangle of uncertainty". It is inside this triangle that the search is refined.

4. Place the receiving antenna framework in this zone and seek a null signal by moving the framework around the vertical axis. It is at the signal null at this point that the beacon emission is located. If the transmitting beacon is installed perfectly vertically, "ground zero" is located.

Determination of Depth

But at which depth is the beacon? The positioning of topography on a chart and the altimetric dimensions of the underground stations can give us a brief reply. The receiving framework will confirm it to us.

Set up a position, along one cord, at point D from the Zero Point. The distance D should be 20 meters.

Position the framework perpendicularly to the cord. The cord is the image of the field line. The signal should be perceived relatively easily. Incline the framework as in figure 4.

When the receiving antenna becomes tangent to the field line, the signal is nulled. Using a protractor centered on the edge of the framework (figure 5), it is easy to read the value of the angle.

The field line is governed by a rather complicated mathematical equation. The depth is a function of the distance and angle of inclination.

The formula is as follows:

$$P = \frac{2D}{\sqrt{9 \tan^2 \Theta + 8} - 3 \tan \Theta}$$

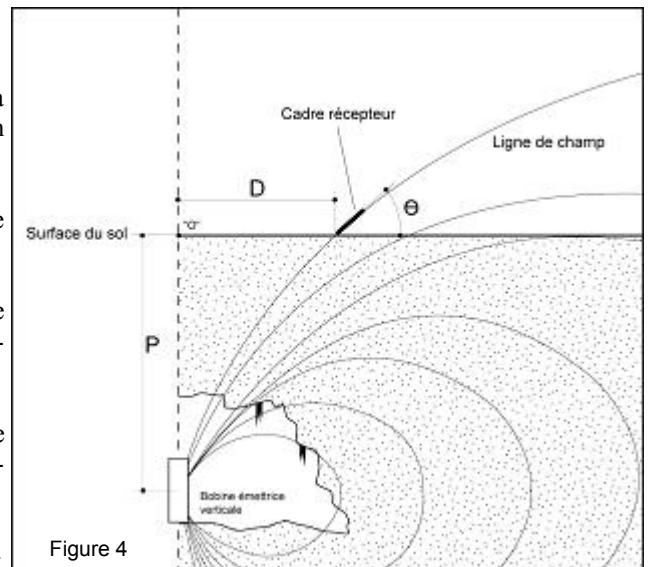


Figure 4

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Since we know the distance D and the angle of inclination, it is easy, with the help of a scientific calculator, to calculate the depth P!

A computed table with the entry of the angle gives a coefficient "K". It is enough to multiply the distance D by this coefficient "K" to find the depth P. The multiplication is easy in the field.

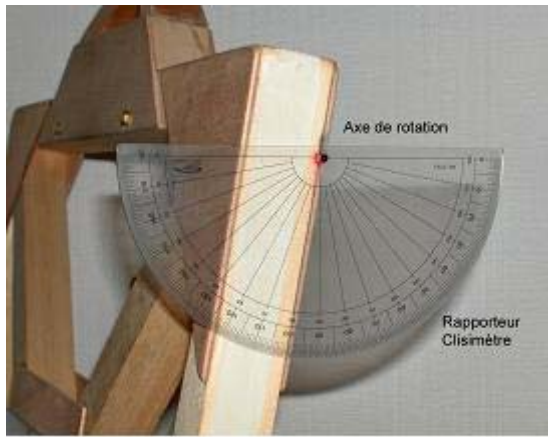


Figure 5

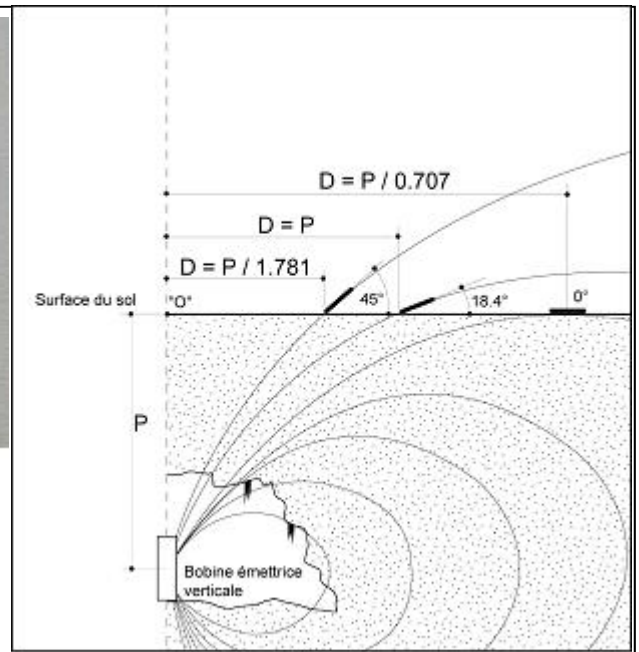


Figure 6

Figure 6 gives examples of particular cases of angles of inclination of the framework for which the signal is null:

- 45° will give a coefficient of 1.781.
- 18.4° will give a coefficient of 1. (The depth P will be equal to the distance D.)
- 0° will give a coefficient of 0.707.

The complete computed table is as follows:

$P = k(\alpha) \times D$		Dizaines de l'angle alpha (α)								
		0	1	2	3	4	5	6	7	8
Unités de l'angle alpha (α)	P = profondeur									
	D = distance									
	0	0.707	0.852	1.031	1.262	1.576	2.033	2.778	4.239	8.565
	1	0.720	0.868	1.051	1.289	1.614	2.091	2.880	4.468	9.523
	2	0.733	0.884	1.072	1.317	1.653	2.152	2.988	4.722	10.72
	3	0.747	0.901	1.094	1.346	1.694	2.216	3.105	5.006	12.26
	4	0.761	0.918	1.116	1.375	1.736	2.283	3.230	5.325	14.31
	5	0.776	0.936	1.138	1.406	1.781	2.354	3.365	5.686	17.17
	6	0.790	0.954	1.162	1.438	1.827	2.430	3.511	6.098	21.47
	7	0.805	0.973	1.186	1.470	1.875	2.509	3.670	6.573	28.64
8	0.820	0.992	1.210	1.504	1.925	2.593	3.843	7.127	42.97	
9	0.836	1.011	1.236	1.539	1.978	2.683	4.032	7.781	85.94	

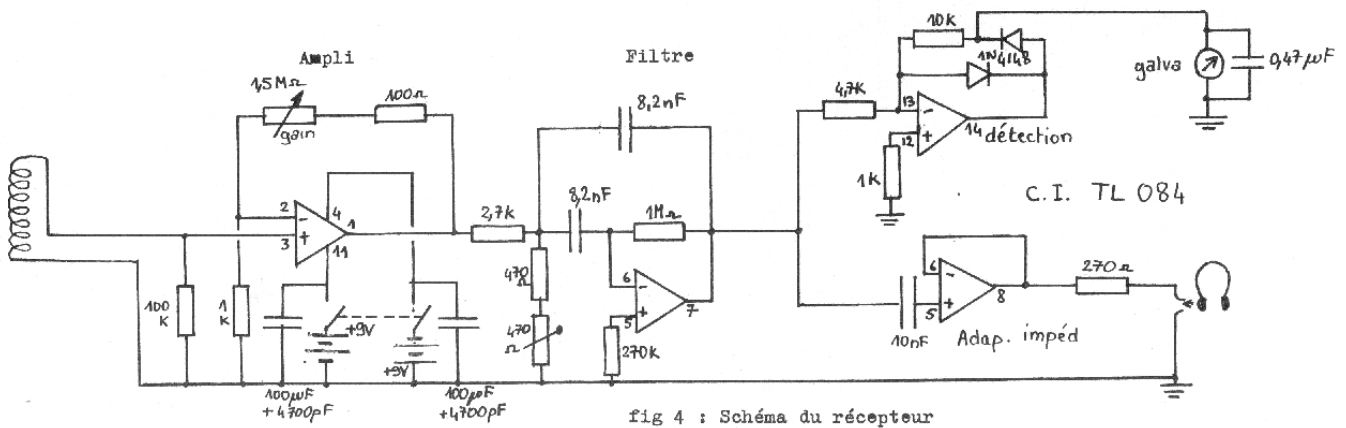


Le cadre récepteur



La balise d'émission (à gauche) sortie de son tube de protection (au centre) et le boîtier d'alimentation 24 volts (à droite)

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The circuit is fed by two 9 volt batteries. The power consumption of the receiver is less than 10 ma.

Field Use

Underground Cavern of Large-Lucé - Sarthe

We tried out this method of radiolocation in one of the underground caverns of Large-Lucé - Sarthe. The beacon had been placed at approximately 25 meters of depth in a room. The survey of the passages led us, on the surface, to a point near the expected signal. The signal was perceived very distinctly. The triangulation made it possible to very precisely find "ground zero" located above the beacon. The depth determination confirmed a thickness of rock of 25 meters.

Cave of Malaval - Lozere

Various electromagnetic locations were undertaken.

Not far from the entry, we wanted to know the origin of the water coming from the ceiling of the small room that precedes the entrance by the "Hole Blower". After having placed the beacon transmitter near the top of the ceiling, we could, with a high degree of accuracy, locate the null on the surface above this point. It is located close to the thicket of trees at the edge of the alfalfa field of the Combes farm.

We also wanted to locate on the surface the survey station RM14 located at the beginning of the higher gallery of the Fossil Shunt. We are in the river. With the surface location of the station, we could reassemble a well up to 18 meters high. The top is clogged by conglomerate. Without any doubt, we are in the presence of an old entry, blocked by calcified fill, a few meters thick. We needed only fifteen minutes to locate this surface point with a very high degree of accuracy since the triangle of uncertainty was only 30 side cm. The depth is 20 meters.

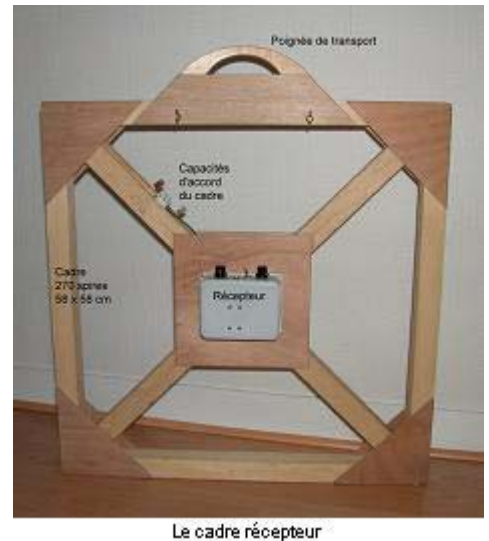
This location is important for the Combes farm since the running water for the farm comes from a polluted source! We will undertake drilling a well and collecting water from the underground river of Malaval to bring drinking water to the farm. Chemical analyses showed the water is potable.

Thanks

I particularly make a point of thanking:

- Commercial Thierry of the Departmental Committee of Corrèze to have made available the plans from beacon ARCANA,
- Pierre Bancel of the Spéléo-Club of the Pond to the Valleys of Franconville to have known to find the 1300 meters of enamelled copper wire of the good diameter,

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- Jean-Bernard Roche of the same club as Pierre Bancel for his contribution to the manufacture of the coil of the transmitter,
- Michel Baille of Association AREMIS to have largely taken part in the realization of the framework of the receiver.

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Taking into account the richness of the publications on this subject, I list only the principal ones here:

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September 2004

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Daniel CHAILLOUX
17 rue Gabrielle d'Estrées
91830 LE COUDRAY MONTCEAUX
Tél. 01 6493 8586
dchaillo@club-internet.fr

Review of the New Leica Disto

John T. M. Lyles

Laser distance measuring equipment (DME), like most high technology consumer electronics, has gotten smaller, cheaper, and better – with all three of these characteristics occurring simultaneously. This is unlike so many things in life. Silicon integrated circuit fabrication is continuously driven, by the market, for electronic systems to reduce size, increase density, and to add features.

Leica, the pioneer in consumer and industrial-grade laser rangefinders, has continued to refine the Disto series of laser DMEs. This report will only discuss the Disto, although Bosch, Hilti, and other companies have produced similar products, some even taking license to put their brand name on a Disto. In the mid 1990s, Disto's were large handheld instruments costing nearly a thousand dollars. By Y2K, the models were smaller, power consumption was lower, reliability higher, and the cost was halved. Two years ago, another step forward produced much smaller units, and the prices continued to drop. The present Leica Disto A2, A3 and Stanley TLM100 are both examples of the state of the art. Mark Kliever at LASERSTREET.COM has an excellent comparison chart on his website, so I refer the reader to this for exact features of each model.

The Stanley TLM series has three models, although I will only discuss the least expensive TLM100 here. The TLM300 has the performance of the Leica Disto A5, both costing \$449 at present. The TLM100, at \$99 or less, is a good deal for what it does, for 40% of the cost of the A2. But it doesn't beep after measurements, doesn't display prior readings on screen, is not sealed from the elements, has no LCD backlight, and requires removal of the 9 volt battery when hauling it in a pack to prevent turn on. It has a minimum to maximum working range of 2 to 100 feet. The operating temperature range is limited to 41 – 122 deg F, for the stated +/-0.25 inch accuracy. In comparison, the A2 has a backlit display, and a range of 2 inches to 325 feet. It also has a limited specified temperature range of 32 – 104 deg F. The Leica Disto A3, on the other hand, is all that the original Disto's and Disto Classic models were, plus some. It is close to the same size as the A2, at 5.3 inches long, 1.8 inches wide and 1.2 inches thick, weighing 5.1 oz. It has the same range as the A2, adds a bubble level and is splash/dust proof. It also operates accurately over a wider temperature range, from -14 to +122 deg F. This means it can be used in cold alpine caves as well as hot vents in Hawaii. For the money (\$299 at present), this is the unit to get for cave surveying. It has an on-screen display of the last three measurements, beep-

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ing after each one is taken. With this addition, I can press the button successive times without looking at the unit, concentrating on keeping the laser spot on target. Usually we use a hand or survey book for a target. A glance at the display will give instant knowledge that the three readings are in agreement (I accept it if it is within a few hundredths, but a few tenths is good enough!). It is important to always take multiple measurements when using hand-held laser DME for a cave survey, as you never know for certain that that tiny spot is “on station”, especially if you are shivering or had too much java in your blood. One has to remember to round up to tenths, since Disto displays to 0.01’ and has a rated accuracy of +/- 0.125 inches out to 325 feet. All of these can be changed to SI units, or even inches and feet if you were so inclined to keep book this way. Going up the product line to the A6 gives Bluetooth wireless output capability, and the A8 includes an inclinometer. These two models are priced like the original Disto: \$649 and \$995.

How has Leica managed to reduce the size and cost of Disto rangefinders? An examination of the guts of a Stanley TLM100 gave me some insight into this feat of engineering. It uses a sealed die cast Leica optoelectronic (OE) module to do the complicated function, range finding and exporting the data representing the measured distance, and a small embedded CPU to handle display, and user interface. The OE module is approximately 3.8 cm W x 3.2 cm L x 2.2 cm thick. There is a small board with a fine pitch flexible circuit to the main PCB. The LCD display sits on one side of the OE module, and has a separate interconnecting flex circuit. The main board has metallization for the pushbuttons (not sealed from environment), LM317 regulator, several other low pin count housekeeping logic and analog ICs and a Renesas (Hitachi) H8/38024 microcontroller with built-in LCD driver. That’s it! The ranging is done inside the Leica OE module. This made the development of the Stanley TLM Fat Max series simpler as Stanley could depend on Leica for the OE and concentrate on the package and CPU.

The Disto Classic and A-series are patented with US 59495331. This was issued Sept. 7, 1999, as a division of US 5815251. That patent, issued a year earlier, was listed on the earlier (larger) Disto classic models. They are virtually the same patents. I discussed details on this patent on the Speleonics email list on 15 April 1999. I summarized it in a review of the Classic3 in CREG Journal No. 43, March 2001. I will summarize it again for this updated report. This base patent discusses using a laser diode with a collimator object lens, a method to modulate the laser radiation, a receiving object lens, and a switchable beam deflection device to generate an internal reference optical path between the laser and the receiving diode. The receiver contains a downstream optoelectronic transducer, with a moving optical deflecting device (mirror, light guide or prism) to adjust the relative imaging position for the incoming light to the transducer, for long and short distance ranging. This counters the parallax problem of having the laser and receiver photodiode separate.

Fluctuations in the laser wavelength and the optoelectronics can introduce phase modulations that, if not checked, can cause up to 1.3 nS delays. This would give an apparent distance shift of 200 mm. An internal calibration method compensates for these fluctuations and drifts by measuring a short internal path through the same optoelectronics. One significant difference between the older and newer Distos is how this internal calibration is implemented.

Pulse modulation of the laser with less than 2 nanosecond pulses is used. Due to fluctuations of the modulation phase from speckle structure (seen in any laser beam), an error of up to 20 mm could be introduced. By exciting the laser with these short pulses, the modulation phase differences from the modes of light reflected and falling on the objective is so that the distance fluctuations are smaller than 2 mm.

World patent WO 9427164 (1994) is similar to the aforementioned patent. WO 9818019 (1998) additionally covers an electronic calibration method, using a mixer, to calibrate for the temperature-dependent phase shifts of the avalanche photodiodes used in the receiver and as the reference detector. This significantly improved the measuring time (~50%), as well as the physical dimensions and cost. The older Disto’s had a motor (more like a meter movement) that flopped across the path with a mirror.

WO 0216964 (2002) discusses the overall method of using phase detection of the incoming reflected radiation with respect to the reference signal (detected from the laser diode in the Disto). This patent discusses the fundamental concept used in the new Distos. While it is similar in principle to the old Disto, use of the electronic calibration mechanism and new electronics has warranted a new patent issuance. And rightly so, I should add.

WO 0244754 (2002) discusses the method of frequency synthesis in the Disto. A quartz-driven ring oscillator is described, which has delay elements (flip-flops) to generate the first high frequency used for the modulation. Using a MUX clocked by a lower frequency derived from the actual measurement, a second high frequency is generated for a mixer. The purpose of all this is to develop the clocks in a simple low power way, while minimizing jitter.

Kurt Giger is the common patentee for the original 1994 world patent, as well as the 2002 overall patent. His name is also on all of the other patents, with a few others. It is assumed that Mr. Giger had much input in the development of Distos for Leica AG.

Something should be said about the ruggedness of Distos. In 2005, a Disto Classic3 got dropped in Lechuguilla Cave. I don’t

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mean dropped from hand to the floor. It came bouncing down a 30 foot pit, as I was below it, hanging on prepared for a falling object to clobber me. Instead of yelling DISTO or even ROCK, the caver just screamed in agony as it slipped from his grip. The worst part of this was that it belonged to the Park Service and it disappeared into loose breakdown at the bottom. We were unable to find it after an hour of searching in circles. Its one thing to bring back a wrecked instrument belonging to the government (believe me, I have had my share of crushed Suunto's), but to return without even a piece of it was extremely poor form. For a few days we reverted to using a 50 foot tape (what's that, you ask?). We had no other options - being at the most remote camp in Lechuguilla Cave for the week. When we had time to look again, after more crawling under the breakdown, the Disto was located, just beyond hand reach. We checked it against our tape, and there was no discrepancy. This incident proved that these Disto's are more than "just a miniature plastic optical bench" inside.

This past summer, Mark Klierer gave me a \$275 trade-in value on my 5 year old Disto Classic3+Stanley TLM100. He added a red Pelican 1030 case, with foam insert, that protects it in my muddy cave pack. The A3 lists for \$299, and with his "caver" discount was ~\$285. My old Disto was in immaculate condition as it had always been carried in an Otter box, and was not dragged in mud. I was happy to upgrade to the A3, from the old Classic3. When I am hauling 35+ pounds of gear for a week underground in Lechuguilla Cave, every square inch and ounce of mass makes a difference. With the new Disto packed, I can afford to bring something else like my camera, which often gets removed during the last minute frenzy to lighten up my pack. I highly recommend the new Disto's. Surf to www.laserstreet.com and check them out.

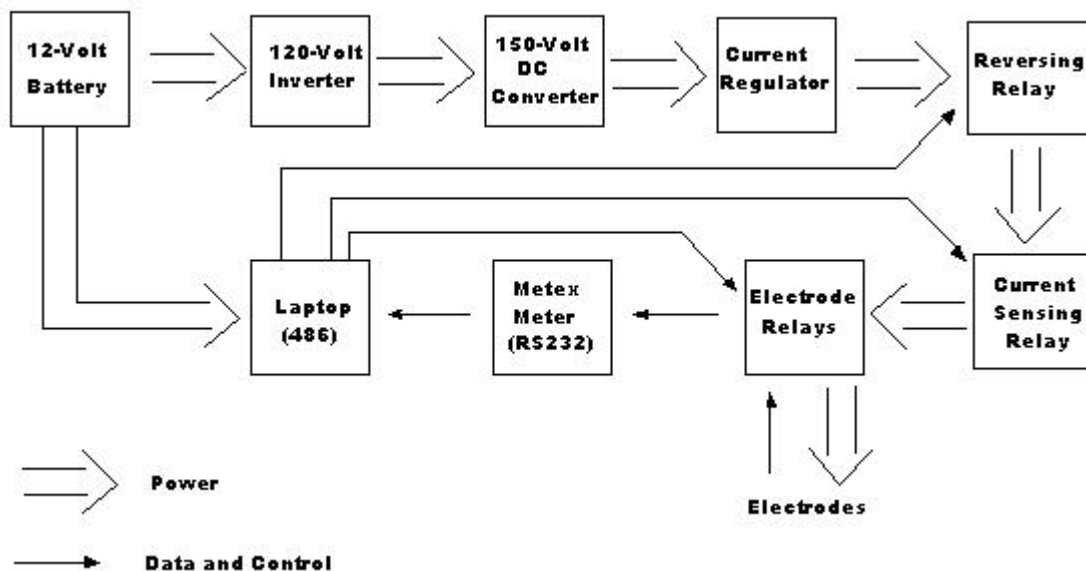
Homebrew Earth-Resistivity Meter

John McLean

9/21/06

Electrical measurements made on the land surface have been used for more than a century to infer the subsurface location of ore bodies (conductive zones) and caves (resistive zones). In the past, only the simplest geometries could be deduced from these surface measurements and geophysicists used simple models and their experience to provide approximate descriptions of the subsurface. However in the last two decades computer programs have been developed that provide rapid inversion of the data – interpretations that are limited only by the accuracy of the data and scale of the measurements. Although these programs are too expensive (\$3,000-\$5,000) for the average caver, they are often released in demo versions (Search on *Res2Dinv* and *EarthImager*) that are adequate for locating caves.

A simple resistivity meter, initially consisting of a battery with a polarity-reversing switch for a transmitter, and a cheap multimeter for a receiver, gradually evolved into the present system shown in this function diagram:



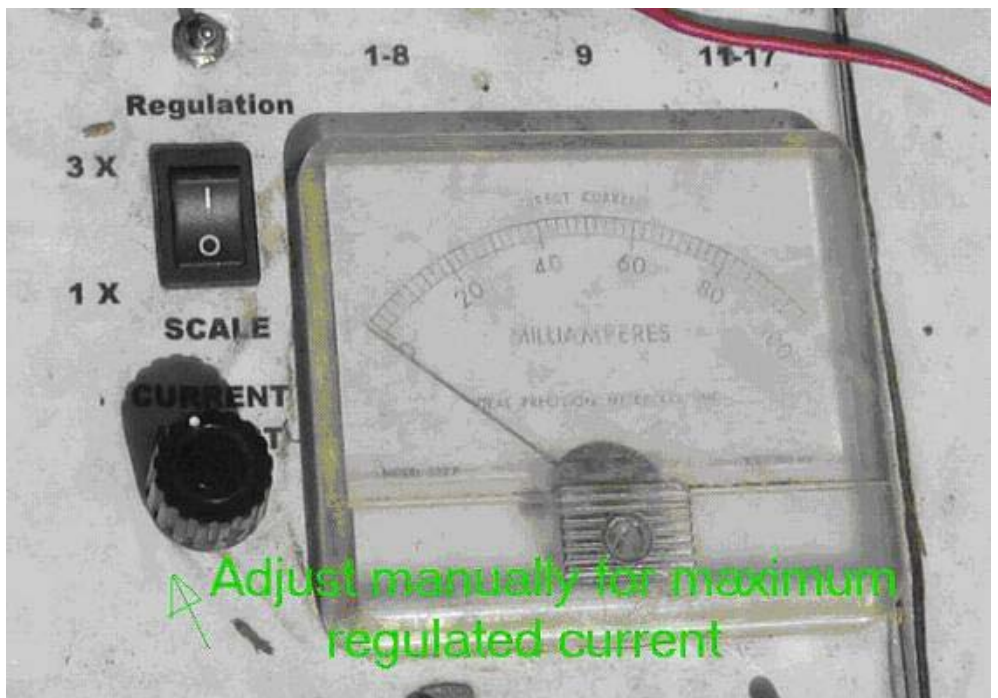
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Much of the system consists of 'off-the-shelf' components: the battery is a 12v, 30 AH salvage gel cell, the inverter is a 200-W Radio Shack special, the meter is a Metex multimeter with serial data out. An obsolete (but compact) Dauphin 486 notebook computer runs the system.

The remaining modules were built on perforated board, strip boards, or single-sided Vector boards using point-to-point wiring. The converter is a simple bridge circuit with large electrolytic caps. The current regulator is a standard op-amp (OP90) driving the base of a large power transistor. A double pole double throw relay is used to reverse the polarity of the current to the transmitter electrodes every two seconds, as discussed below. A current-sensing relay simply shunts the voltage drop across a one-ohm resistor to the Metex meter so that the current to the transmitter electrodes can be measured. The electrode relay board consists of a bank of double pole double throw relays driven by small signal transistors controlled by a 74LS154 one-of-sixteen data distributor TTL chip. The board switches the transmitting and receiving electrodes into the circuit in pairs. The parallel port of the computer is used to control the relay board through the TTL chip, and also to control the reversing and current-sensing relays.

A QBASIC program running on the laptop handles the electrode switching through the parallel port, receives the data from the Metex meter through the serial port, averages the results, computes the apparent resistivity, and formats the results for entry in the interpretation program. The modules are cabled together in a plastic toolbox:



A significant expense in commercial resistivity systems is the multi-drop cable used to connect the electrodes to the transmitter and receiver. This expense was avoided by using inexpensive CAT3 four-pair cable, slitting the outside sheath, stripping one of the wires every 15 meters, and soldering on a two-foot pigtail lead. Two of these cables, plus a center electrode connected directly to the unit provided an array of 17 electrodes. Standard, inexpensive, DB-9 connectors were used on each end of the cable, allowing the lines to be extended by picking up one cable and 'leap-frogging' past the other end of the line (roll-along operation). The rig is completed with the addition of 18-inch electrodes cut from standard copper-clad steel grounding rods, and two-gallon bleach bottles containing a salt solution. The total field weight of all components is about 100 lbs, and the cost of materials is less than \$300.

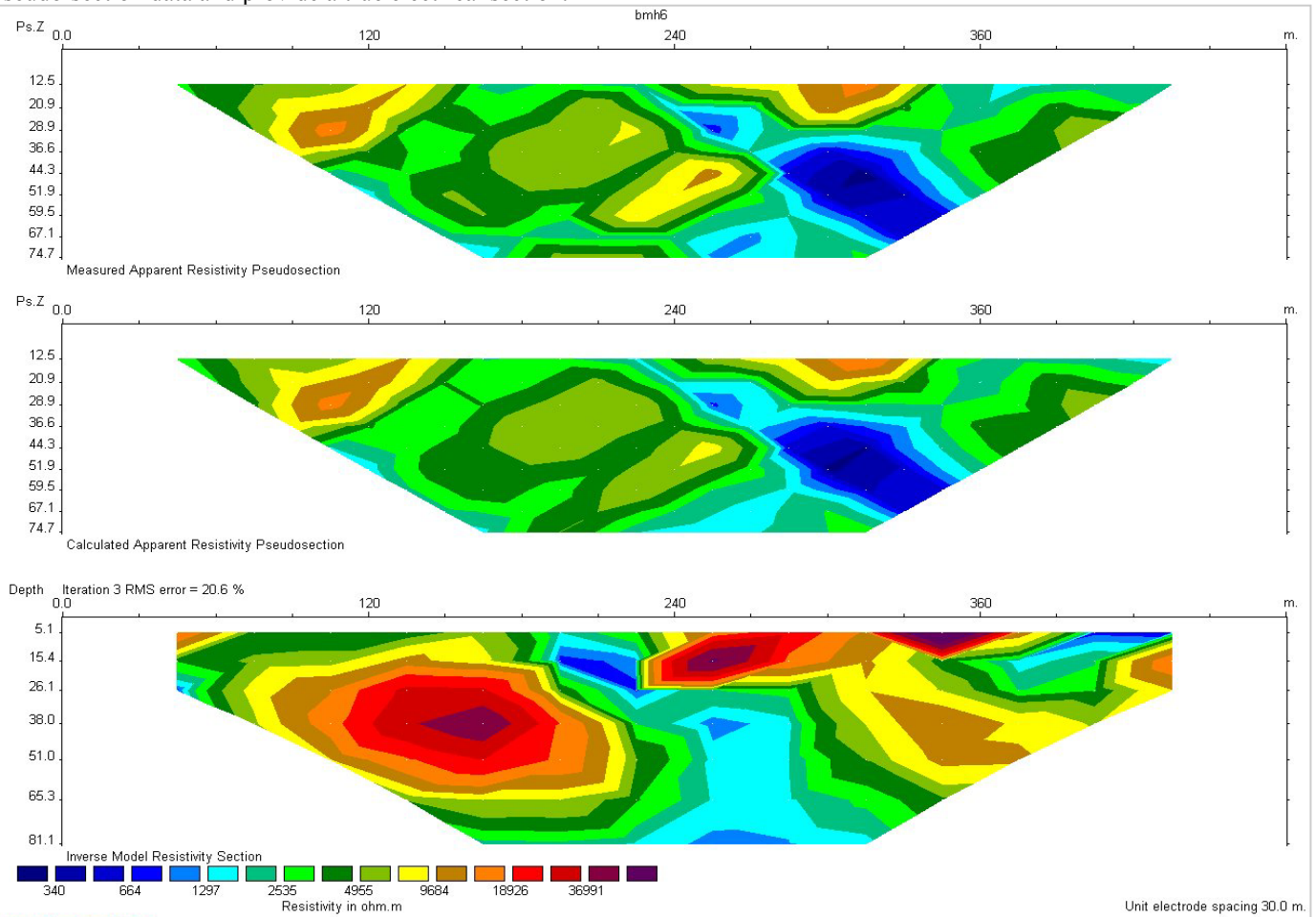
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In operation, the cables are laid out in a straight line, electrodes are driven into the soil at each pigtail 15 meters apart and at the center station. The earth at each electrode is saturated with a cup or more of salt solution to ensure good contact between the electrode and the earth. The electrode pairs are then tested to determine the maximum regulated current that can be transmitted. The current is increased, using the pot connected to the op amp, to the maximum. After all electrode pairs are tested, the pot is backed off about one third from the smallest value of maximum current measured for any pair. This ensures that the current will be in the 'regulated zone' for all electrodes.

This part of the process is manual, rather than automated. The program then steps sequentially through the electrode pairs, collecting current and potential data.

Two current measurements are taken and averaged, followed by ten potential measurements in pairs (forward and reverse current polarity). The differences between the five pairs is then averaged and divided by the average current to give the apparent resistance. This resistance is multiplied by a scale factor that increases exponentially with the separation between the electrode pairs to yield a value of 'apparent resistivity' that is equivalent to the resistivity of a uniform, infinite half-space. A maximum separation of six inter-electrode spacing ($a = 6$) between the transmitting and receiving electrode pairs is allowed before the signal strength falls too low. When the apparent resistivity values are plotted at the intersection of a 45-degree line between the transmitting and receiving electrodes, a 'resistivity pseudo-section' results. This pseudo-section is not at all equivalent to a true geologic section. Thirty years ago geophysicists would have applied their experience with field problems and a few simplified numerical models to infer the approximate geology represented by the pseudo-section. Today, numerical models are available to directly invert the pseudo-section data and provide a true electrical section.



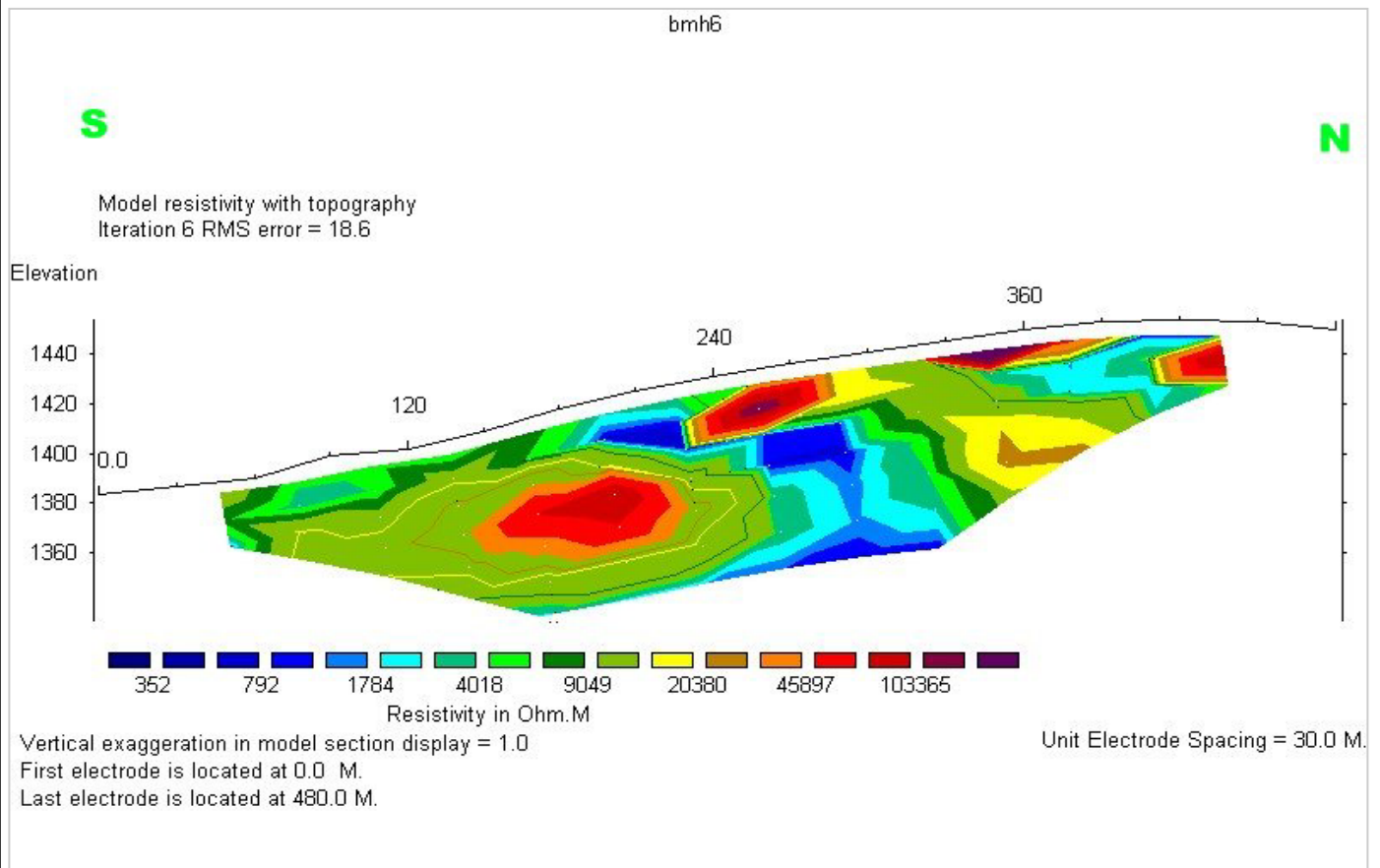
These sections, derived using the Res2Dinv demo, show the results of a line at Big Manhole Cave, near Carlsbad Caverns NP, New Mexico. The top section is a pseudo-section of the raw data. The middle section is a smoothed representation of the upper section which the software will use a target for an iterative solution. The bottom section is the result of three passes through the sequence of inverse and forward solutions (the maximum number of iterations available in the demo).

Resistivity increases from blue to red in these sections, so that the red, most resistive zones probably represent cave passages.

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Note that the location of the large cave passage shown on the bottom section would be very difficult to infer from the upper pseudo-section. Adding the surface topography along the line and iterating to a final solution using the full version of Res2Dinv (thanks to Dr. Barbara Luke at UNLV) produces this adjusted electrical section:



Although this section was generated using twice the number of iterations, the location and depth of the presumed cave passage are about the same. This is typical of many lines, and indicates that the analysis provided by the demo software is sufficient to at least provide a direction for cave digging. Analysis software that will allow more complete data reduction, using multiple techniques, is under development by cavers and will be freely available when finished.

The present system has many limitations that I hope to remedy in the next version. The electrode spacing is fixed for any given line, due to the pair-by-pair switching imposed by the relays. It would be better to have the current and potential electrodes individually switchable, so that a 15-meter electrode array could be used to also collect some deeper points using 30-meter spacing. There are a few low-current solid-state relays that are not too expensive available that may work for this. The potential electrode switching may be handled by a mux. Current-limiting resistors are also needed, as it is now possible to kill the regulator when the stake resistance is too low – immediately after a rain, for example.

John Lyles pointed me to a high-quality, 300-volt power supply on eBay that I hope to use in place of the inverter/converter combination.

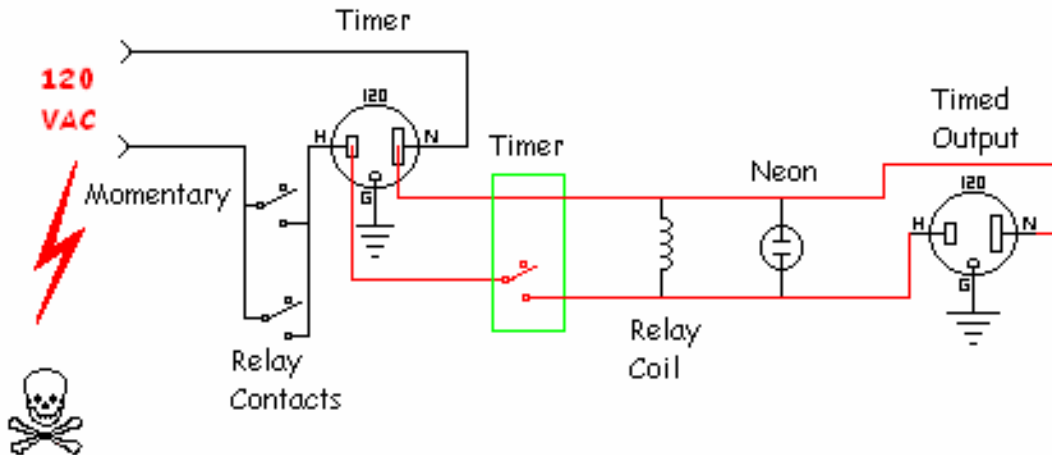
Comments and suggestions (to johnmclean@interfold.com) by the electronic cavers are always welcome.

AC Mains Timed Output Controller

Paul R. Jorgenson KE7HR NSS 39382

There are many times, especially with battery chargers, that a certain amount of time needs to be delivered to a device from the AC mains. It is possible to just use a mechanical interval timer of the kind that people use to turn lamps on and off to make their house look 'lived in'. This sort of scheme will keep turning the device (battery charger) on every day. The user needs to remember to take the battery off of the charger after it is through charging and before the next cycle starts to prevent over charging.

I remembered a circuit from many years ago (and do not know to whom to attribute this to) that would use a small relay and use the mechanical lamp timer to latch the relay until the timer output went off, there by turning off the input to the timer. Here is my version.



Timed AC Mains Outlet - KE7HR

CAUTION! This circuit uses dangerous voltages!

The 120 volt AC mains power comes in to the timer socket and a momentary switch. Closing the switch energizes the timer socket and therefore the lamp timer. When the timer is activated the power can flow to the relay coil, closing the contacts of the relay which also energize the timer socket. While the timer is energizing the relay coil it is also allowing power to flow to the Timed Output socket and lights up a neon light to show that the timer is active. Releasing the momentary switch does not shut the Timed Output socket off since the relay is keeping the Timer Outlet energized. When the lamp timer opens it's switch turning off the Timed Output socket, the relay coil also de-energizes which opens the power line to the Timer socket.

Set the lamp timer for the number of hours that the output (battery charger) should be on and then press the momentary switch to start the timing. I generally set the lamp timer to midnight so it is easier to count the number of hours to be used!



Lithium 123 Cells with Caving Headlamps

John T. M. Lyles

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Three years ago, I modified a Petzl MYO 5 to accept a 1Watt Luxeon LED in the central position as a spot beam, while maintaining the original five white LEDs of the MYO 5 circuit [1]. To power this system I had continued to use the same four D cell Justrite battery box that I had used for the past 10 years with incandescent bulbs. This article describes using lithium-manganese dioxide CR123A cells, including construction ideas on how to package them compactly in a cave-proof housing. I constructed the battery container two years ago, and it has been extremely robust without problems. I use primary (non-rechargeable) cells, “primarily” because I tend to enjoy week-long expedition caving, where the advantage of using more expensive rechargeable batteries is negated without access to an AC outlet. It might require additional sets of rechargeable cells. One caver on my team is now using his Sten light, with 3 rechargeable batteries, for the same duration that I am using 6-7 pairs of CR123A’s. They’ve come a long way. The trick is to not run maximum brightness all the time.

Any comparison of alkaline-manganese dioxide and similarly sized lithium-manganese dioxide primary cells shows that the latter offer significant gains in energy density, offering similar or better amp-hour capacity with a fraction of the weight. However, the terminal voltage of the lithium chemistry is twice that of the alkaline, so that the energy capacity in Watt-hours (Wh) is increased. Comparing sizes of cells and the Wh versus mass (gravimetric) and volume (volumetric), we find that the best (Duracell) alkaline D cells have about 27 Wh of capacity, or 130 Wh/kg and 322 Wh/liter. They weigh 139g. Alkaline cells in AA size offer 143 Wh/kg or 428 Wh/liter. They weigh 23 g. In contrast with these figures, Lithium primaries offer a whopping 247 Wh/kg and 540 Wh/Liter, weighing 17 g, according to Melzer [2]. From this it can be seen that the small Li-MnO cells have more capacity for their given mass and volume. Now, combining cells to get 4-6 volts for my buck regulator LED current supply, four D cells weigh 560 g. Four AA cells weigh 92 g. Two CR123A’s weigh 34 g.

There is the convenience factor of being able to obtain alkaline cells in villages in nearly every country and convenience store. Prices are typically reasonable when they are purchased in advance in quantity packs such as from Wal-Mart or Costco and other “big box” stores. Shelf life, however, is not as good as the lithium technology. According to Bedford [3], alkaline batteries have 85% self discharge after 5 years, while lithium-MnO has a long life, with a quoted 10 year shelf life to some unspecified voltage.

Fortuitously I learned from the candlepower forum [4] that CR123A’s can be gotten via the internet in quantities as low as \$1.25 per cell. Some good sources are www.surefire.com, www.batterystation.com, and www.batteryjunction.com. I bought twenty Sanyo brand 123’s to test and use caving. Finding a suitable ready-to-use battery enclosure for these cells presented a problem. I will now describe how I designed and constructed a solution.

Construction

A small Hammond 1590-series cast aluminum box is used, measuring 2 x 2 x 1.2 inches thick. To mount it permanently on a helmet, it needs studs through the base. I chose a pair of 6-32 spade-end bolt, fastened to the side-walls on two sides. Figure 1 shows the original box, with one spade-end bolt in place. The base is drilled and tapped for tiny 2-56 screws, to hold down the battery holders. Figure 2 shows the box with one stud protruding through the base, while figure 3 shows the interior detail of mounting this stud. A single nut is required between the spade end and the case, to space it properly so that the screw clears the corner of the box. The screw holds the spade in place, fastened with a nut. There are other methods to add fasteners to the box, such as welding, or using an elastic band to hold it to the helmet like the commercial headlamps use. Advantages of these would be a removable battery container. I am a stickler for having a solid setup without dangling parts from my helmet while caving. I also prefer to have the hardware bolted to my helmet with the smallest protruding hardware inside of the helmet, for safety reasons. Having it low near the rim and on the side is preferable to having hardware mounted directly on top of your head, to be driven into your skull when you take a bumpin’ on your noggin’.



Fig. 1,
one spade screw mounted



Fig. 2,
outer view



Fig. 3,
interior detail of spade screw



Fig. 4, bottom of box drilled and
tapped for battery holders

(Continued from page 14)

The Keystone battery holders are called 2/3A size. I found them a few years ago but now they seem to only offer a plastic part with PC board pins. Some looking around might turn up more of the aluminum clips. They are modified by removing one of the side clips from opposite sides of each battery holder. Otherwise, they will not fit into the box, and the batteries will be crushed when inserting them. Figure 4 shows the two Keystone holders beside the box, before the ears are broken off. The four smaller tapped holes for the 2-56 screws are off the centerline of the batteries so that the heads will not cut into the cases and short out the batteries.

Once the box is drilled and tapped for the tiny 2-56 screws for the battery holders, a hole was drilled for a tight-fitting Heyco strain relief on one side for the cable. The mounting studs should be tightly installed with a lock washer, so that they won't work loose later. A layer or two of heavy vinyl tape is applied to the inside surfaces which are adjacent to the battery posts. I used a freeze-resistant heavy vinyl tape. This is necessary to prevent short circuits when the batteries are inserted. When attaching the studs and battery holders, I used Marine Goop sealant, as an adhesive/sealant on the threads.

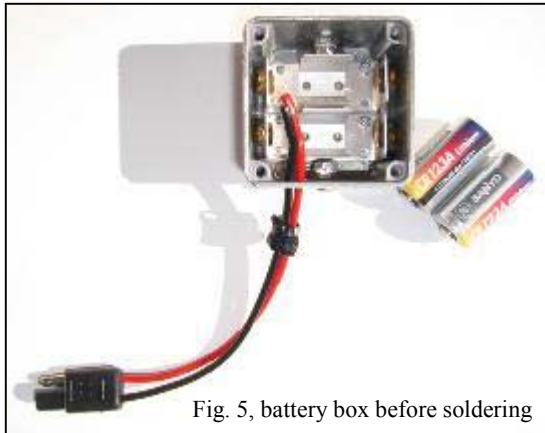


Fig. 5, battery box before soldering

The circuit is simply a series connection of the two cell holders, with a tiny 2 Amp Pico Fuse for the link between the holders. This affords some protection should a direct short circuit occur. If the fuse were to blow, however, I would be without light until I could solder a jumper. It might be better to use an automatic resettable PTC device like Raychem makes. I wanted the highest efficiency with my system, so I chose the fuse. Being a floating system (neither end of the cells is connected to the case), the only way to cause a short circuit would be to connect a conductor across both output posts on the batteries.

I painted polarity symbols inside the holders to prevent damage to the electronics from mistakes. A protective device such as a series diode in my headlamp would prevent this from occurring, but electrical efficiency was a primary goal.

Figure 5 shows the mounted components before wiring or removing the inner ears on the battery holders. Figure 6 shows the completed mounted assembly, with all wiring in place, and the ears removed. Instead of using the supplied recessed flat head screws for the lid, I used stainless steel Allen-head cap screws, which have a small knurled head for finger tightening or use of a Leatherman tool.



Fig. 6, wired and mounted

A small O-ring is seen on each screw in figure 7. This helps to seal and hold the screws in place in the countersunk holes in the lid, making "finger tightness" adequate for caving. The 1590LB box is not waterproof, although a gasketed version is available. The two holes for the spade bolts and the cord strain-relief would need to be coated with a sealant. For the kind of caving I do, mostly in the Southwest, I am rarely immersed in water. I just remember to open the box and let it dry if I hose it off to clean it.

Parts List

- 1 Hammond 1590LB die cast aluminum box, Newark Electronics 81F3739@\$7.96
- Two Keystone 132 aluminum battery clips for 2/3A size
- Two 6-32 x 3/8 inch spade-end bolts
- Four 6-32 nuts, smallest size
- Four 2-56 binding head Philips machine screws
- Four 6-32 Allen head cap screws, stainless steel
- Four small rubber O-rings
- 1 Heyco strain relief bushing
- 1 Workman 2 pole 16 AWG power plug, or equivalent
- Insulating rubber or PVC tape, preferably several mils thick
- One 2 Amp Pico Fuse

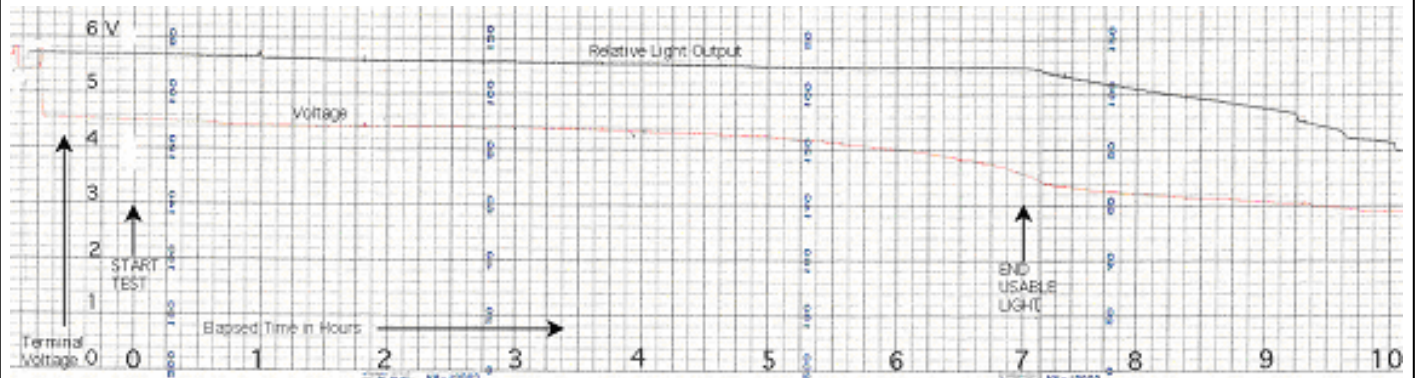


Fig. 7, cap screws

(Continued on page 16)

Results

Before taking this battery system caving, I ran a load test while recording battery voltage and relative light output as seen by my reference photodiode. It would be unfair to test the cells under continuous full power operation as I only operate my PWM dimmer and 1 watt LED at full power intermittently, when looking at ceilings, high leads, down pits, etc. I chose the middle set-



ting for the MYO 5 LEDs, as this presents a reasonably constant 80 mA load, until the batteries fall off significantly. This approximates operating the PWM dimmer on the Luxeon at $\sim 1/2$ power. While surveying I often dim my light more or operate the MYO 5 LEDs on low setting to save power. That is about 40 mA of drain.

From the chart, it is evident that the initial voltage is only 4.5 volts for two cells, when the light is turned on. This may be a result of the particular cells being old or just high internal resistance with this load current. With 7 hours of life based on this bench test, I began field testing the rig. The light output was excellent for 12-14 hours of normal use at which time I noted that the low, medium and high output for the MYO 5 leds were all similar brightness. This simple battery system is adequate for most day caving, costing a little more than alkaline batteries at about 1/3 the weight in the battery box on my helmet. For multi-day expeditions this system has proven to be 'the cats meow'. Since developing this battery system along with the dimmable LED/MYO 5 headlamp, I have gone on a half dozen eight day expeditions and used between 10 and 14 cells each week, just over a day per set of two. My spare battery kit for a week is slightly smaller than a box of kitchen matches. It would be simple to remove the small box from my helmet and plug a different cord into the harness for another battery box, either belt-mounted, or on the helmet. With 123's selling for \$1.25 - 1.75 each, I don't think I need to.

References

[1] Lyles, J., "A Luxeon LED for the Petzl MYO 5", Speleonics #25, 2005, pp. 20-24, available at <http://www.caves.org/section/commelect/spelonic.html>

[2] Melzer, M., "Lithium Ion Batteries for Caving Projects", BCRA Cave Radio and Electronics Group, Journal 59, March, 2005, pp. 14-16.

[3] Bedford, M., "From Alkaline to Zinc Air- an A to Z of Batteries", BCRA Cave Radio and Electronics Group, Journal 34, Dec. 1998, pp. 8- 12.

[4] www.candlepowerforums.com



An HF Portable Antenna

Paul R. Jorgenson KE7HR NSS 39382FE

The need arose for a compact, cheap, antenna for the 75 meter HF amateur band to be used for cave radio communications. Full size antennas are a bit awkward at 75 meters. (The 75 or 80 meter amateur band in the USA extends from 3.5 to 4.0 MHz.) Good success was seen with a MFJ 1988T portable telescoping antenna. This base loaded antenna costs about \$129 USD and is usable on 80 to 10 meters. I wondered how hard it would be to homebrew a single band antenna for 75 meters to work with my low power single band radios.

Radio Shack (US) had some telescoping replacement antennas on sale. I picked up a model 270-1408B that extends to 6 feet (1.82 meters) and collapsed is about 14 inches (.35 meter). This seemed like a good starting point. Other items that I had were 1/2 inch schedule 40 PVC water pipe, a panel mount BNC connector, and #22 solid insulated wire. Now it was time to put it together.

I did not want to make the loading coil too much longer than the telescoping section. I close wound the #22 wire on the pipe for a distance of about 18 inches (.455 meter). The winding turns out to have 82 uH of inductance as measured by my BK 878 meter. Attaching the telescoping section to the pipe (while inside my house) gave success. Varying the length of the telescoping section was obviously changing the resonant point and the signal strength was good. I wrapped the coil section with white electrical tape. The screws that I used to mount the BNC to the pipe were long enough to have a wing nut on the back side. This easily allows the attachment of a counterpoise, which is needed. The recommendation from MFJ is to use a counterpoise that is calculated using $(180/F \text{ MHz})$. This works out to about 50 feet (15.2 meters) at the 75 meter band segment.

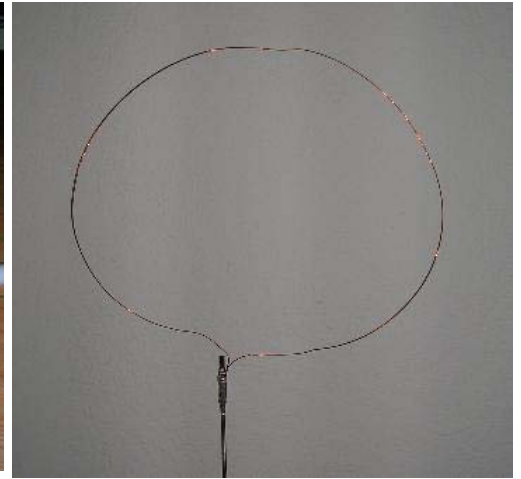
Now time to take it outside and make it play with the radio. Setting up was disappointing - I could not get the antenna to resonate. My initial testing inside the house apparently had the effect of adding capacitance to the circuit. I found that the resonant point with the full extent of the telescoping section was about 3.9 MHz - 400 KHz too high for the digital segment of the band meaning the antenna was too short. I clipped a section of wire to the top of the antenna and could get it to resonate down in the 3.5 MHz range. Searching around in the garage for ideas, I came across a piece of aluminum tubing that the telescoping section would fit into without too much slop. A few taps of the hammer and it was quite snug. A 20 inch (.51 meter) section of the tubing was cut. I flattened one end to attach to the top of the PVC pipe and drilled a hole to secure the telescoping section at the top. Now I had more than enough length and the antenna would resonate all across the 80 meter ham band.

Tuning is initially accomplished by changing the length the telescoping section a small amount at a time while listening for an increase in signal strength. Fine tuning can be done with a SWR meter and the transmitter on low power. Don't touch the antenna while transmitting! Not only will it be detuned, but a RF burn will be your reward! I have been able to get a 1:1 SWR all across the band. I have run as much as 15 watts power to this antenna with no visible ill effects, but expect that it is just a QRP or low power antenna.



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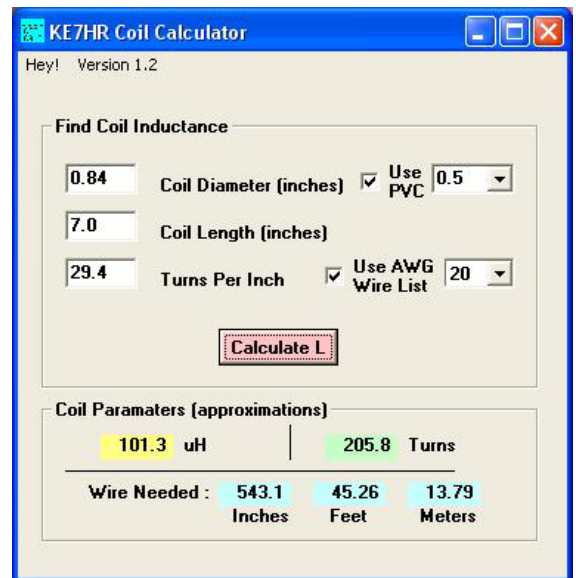
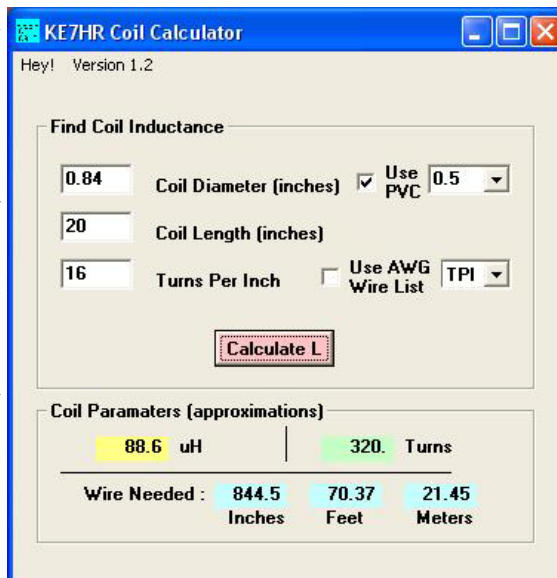
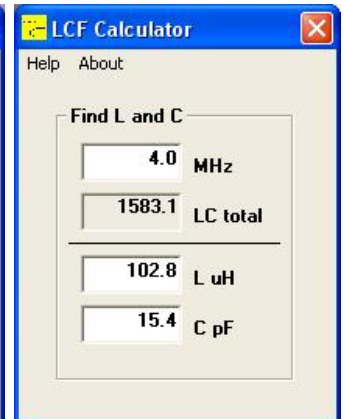
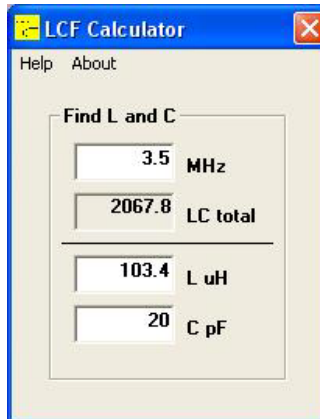


To support the antenna, more PVC comes to the rescue. I cut three lengths of pipe about 12 inches (.3 meter) and one length about 1 inch (3 cm) long. A purpose built, \$5, PVC pipe cutter is far superior to using a hacksaw for making accurate and clean cuts. These lengths are placed in a 4 way PVC connector. The shortest length has a 90 degree connector that the bottom of the antenna pipe sticks into. Not gluing the pieces allows angle adjustment for uneven ground. The whole package collapses together nicely and fits easily into my pack. I tie the pieces together with hook and loop fasteners that are two sided. \$10 in parts for a portable antenna. This is one of the antennas that was demonstrated at the 2005 Convention Radio Field Day.

Before building another version, I wrote two computer programs (LCF Calculator and Coil Calculator) to help model the antenna circuit and allow other designs to be considered. The antenna circuit appears as a resonant circuit with a direct relationship between the Frequency, Capacitance, and Inductance. Since I measured the inductance of my first coil at 82uH, and the resonant point of the non-extended pull out antenna section was 3.9 MHz, then the pull out antenna had to be acting as a 20 pF capacitor. Reducing the length of the pull out sections reduces the capacitance. Since the maximum capacitance of the pull out section was now calculated, changing the design was a matter of trying other combinations of coil size and wire diameter (and insulation) for the inductance portion of the antenna.

I have built several other versions of the antenna using both plastic insulated wire and enamel covered magnet wire. I have also gone to more available, more robust, stainless steel replacement antennas from the auto parts store. A couple of the design examples is given by screen shots of the design programs. The smallest example was made with #20 magnet wire on 1/2 inch PVC, making the coil only 4 inches long. This extreme example had trouble resonating with the pull out antenna section and needed a "capacity hat" or coil of wire at the top to get the SWR to a reasonable value.

A tuner is required to effectively work underground since the passage size and other variables tend to detune the antenna. A very small QRP (low power) tuner made from poly variable capacitors and a tapped coil wound on a toroid has worked very well and is small enough to fit in the cave pack.



Homebuilt HF Radios for Use Underground

Paul R. Jorgenson KE7HR

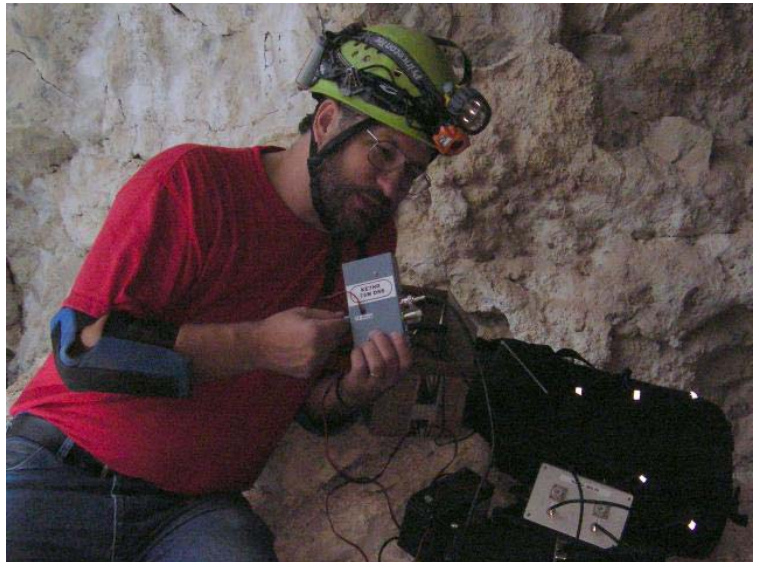
With the good success in using Amateur Band HF radio for underground communications, I started looking for cheaper alternatives to the \$500+ commercially available radios. My first project was to build a DSB (Double Sideband) transceiver. DSB is easier to build due to fewer parts and so less expensive to build than a SSB radio. I found a suitable looking project on the internet called "Wee Willy 75 Meter DSB Transceiver" (<http://www.qrp.pops.net/willy.asp>). It seemed to meet all of the needs for a caving radio - small, light weight, simple to use, not too costly, and easy to build. The first project ended up costing about \$50.

DSB suppresses the carrier frequency, but passes both sidebands (the parts with the voice information) at once. A SSB radio (Single Sideband) suppresses the carrier and one of the sidebands so it only transmits one or the other (upper sideband or lower sideband). If the carrier frequency was not suppressed nor the sidebands, the transmission would be the familiar AM or amplitude modulated transmission. DSB is more efficient than AM and SSB is more efficient than either. DSB is a compromise between a full blown SSB radio and an AM transmitter, but still useful. Users of SSB radios will not know that you are also transmitting on the 'other' sideband!

I chose to use the 'ugly' or 'dead bug' style of construction. I built the receiver and transmitter on different small bits of printed circuit board. The frequency determining part (crystal control or variable oscillator) was something that I wanted to experiment with, so I designed so that it would be outboard from the main parts of the transceiver.

Looking at the circuit diagram and reading the text of the project, I decided to modify the amplifier section so that it ran from the 12 volt battery. I used a voltage regulator to keep the voltage safe for the mixer, a NE602. Since I only had 5 volt regulators, I used the old trick of putting a switching diode in the ground lead to raise the output voltage by the forward conducting voltage of the diode. I used two diodes in the transmitter circuit and one in the receiver circuit. See the schematic for my changes to the circuit in red. This modification allows the transmitter to put out about 2 watts - double the original! I also found the regulator needed an additional bypass capacitor to stop instability. I substituted a different transformer than that called out for, which worked quite well. I made the operating frequency switch between the transmitter and receiver with the TR or transmit-receive switch.

Tests with the radio and a dipole antenna showed that the receiver (a direct conversion circuit) was wide banded and was able to hear transmitters off frequency a bit. It was, however, quite sensitive - the first night I had it together I was hearing station from TX, OK, NM, CO, AZ, NV, and CA from my home in Phoenix, AZ. I had to turn down the RF gain control to have comfortable listening to the louder stations (which also saves a bit of battery power). For portable use, headphones will work fine but the audio amplifier has sufficient output to drive a small speaker to a good volume. The RF gain controls the volume as there is no 'volume control' on the audio amplifier.

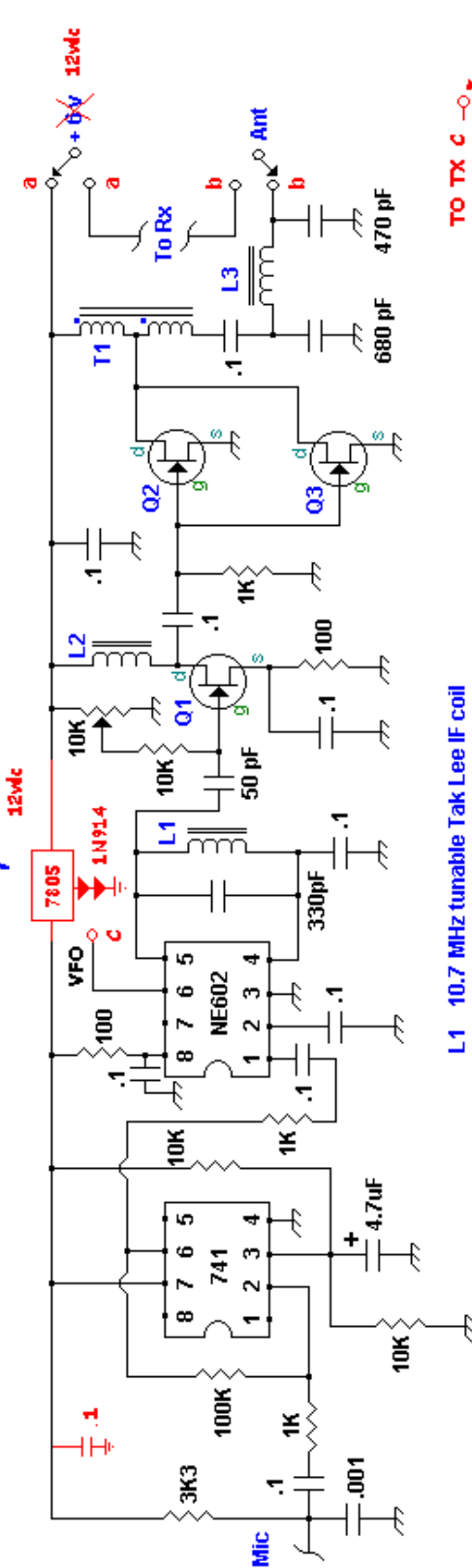


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The transmitter has a similar power level to the FT-817ND that I used underground on other occasions. The photo on the top of the page shows me speaking to the surface 220 feet above with perfect clarity.

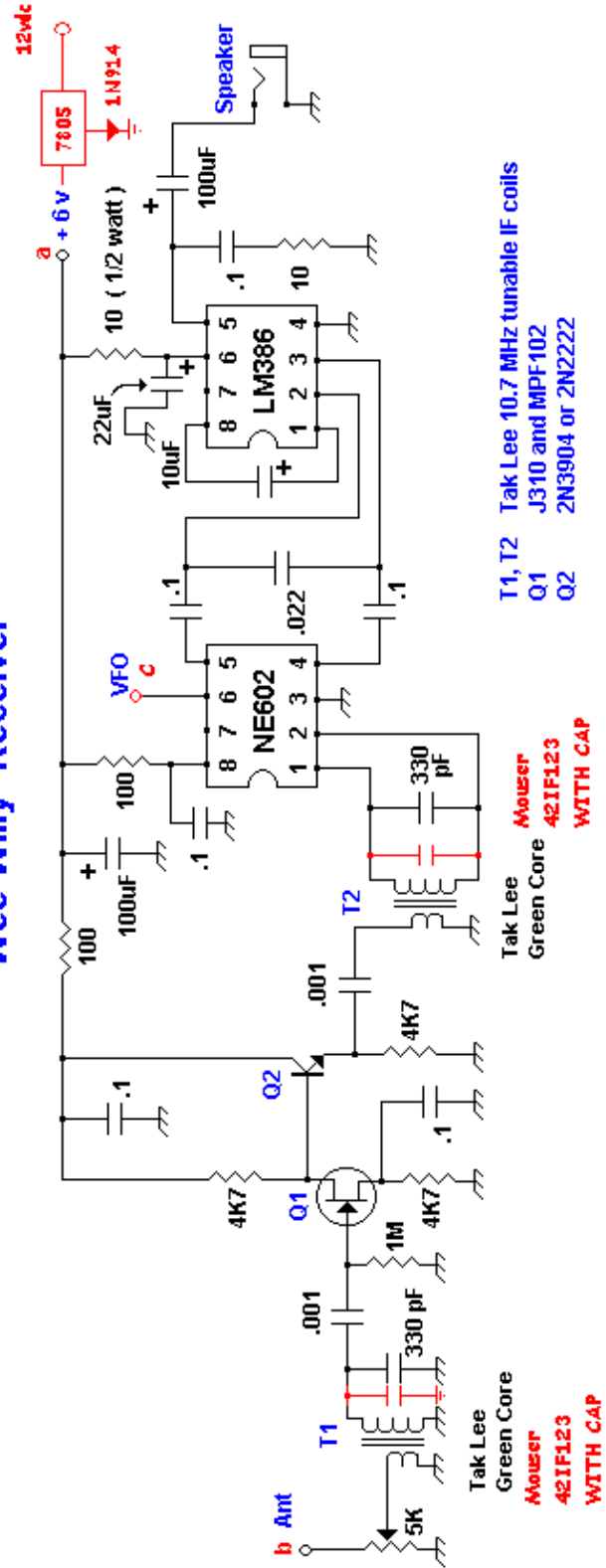
Wee Willy Transmitter



TO TX C — 1N914 — VFO
TO RX C —

- L1 10.7 MHz tunable Tak Lee IF coil
- L2 47 uH RRF Choke
- L3 22 turns #24 AWG on a T50-2 Powdered Iron Core
- T1 T1 is 6 turns Bifilar wound #24 wire on FT37-77 core
- Q1 - Q3 VN10 nJFETS

Wee Willy Receiver



- T1, T2 Tak Lee 10.7 MHz tunable IF coils
- Q1 J310 and MPF102
- Q2 2N3904 or 2N2222

- Tak Lee Green Core
- Mouser 421F123 WITH CAP

- Tak Lee Green Core
- Mouser 421F123 WITH CAP

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After building the DSB project, I wanted to try building a SSB rig. I searched the internet for a simple circuit that would be easy to duplicate and have a fair chance at success. My search narrowed to a design by Steven "Melt Solder" Weber, KD1JV. Steve keeps a website with projects at <http://kd1jv.qrpradio.com/> that had a 'Fairly Simple SSB Rig with PTT for 75 Meters' project that sounded exactly like what I was looking for. When Steve published the printed circuit diagram for the 'Revised (Fairly) Simple SSB Rig' (with a separate final amplifier), I started building.

The radio is a single conversion super-heterodyne radio with a 5 MHz variable frequency oscillator (VFO) which mixes with a 9 MHz intermediate frequency to produce the approximately 4 MHz lower sideband signal in the 75 meter ham band. The project VFO was actually a PTO or permeability tuned oscillator that was stable on the workbench but not great in the field. More on that later.

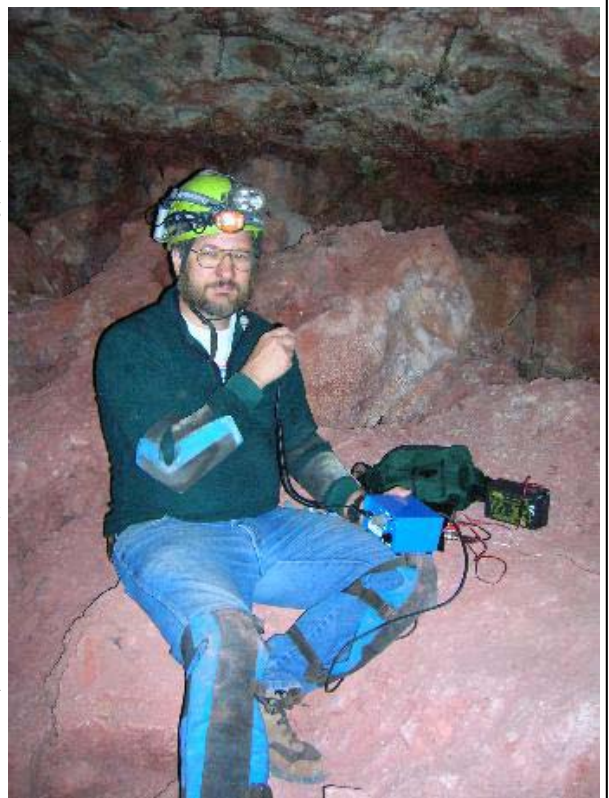
The radio features a four element crystal filter to select the proper sideband. The filter, and other parts of the circuit, is switched between transmit and receive by an analog switch IC circuit. This works quite well. NE612 mixer chips are used for both transmit and receive circuits. They are very reliable and widely used in amateur circuits, but may become more scarce in the future like all IC chips...

I found one tiny error in the PCB artwork - one bypass capacitor, next to the voltage regulator, did not have pads for drilling. I just added the part to the underside of the board, since it is small. I did not have the 7mm IF transformers that were called for so instead used 10mm transformers that I soldered extensions, made of resistor lead cutoffs, to fit the board. The wires could be bent into place, but it would have been nicer to have the smaller part. All of the other parts went on the homemade PCB quite well.

I purchased a couple of cheap speaker microphone combination units on eBay. To keep the project compact I wanted to use a speaker mic instead of having to fit an internal or external speaker. This presented a problem as the circuit did not completely mute the input to the audio amplifier. Depending upon the microphone gain and speaker volume, the speaker would feedback and howl like mad, but only with the speaker mic and not an external speaker. After a bit of head scratching, I came up with a scheme to ground the input to the audio amplifier using an additional 2N7000 transistor which is switched along with the transmit-receive changeover. This solved the problem (and I later found out that Steve had the same problem and solution).

One more change that I made was to allow a switched gain increase of the audio amplifier from 20 to 200. All this took was the switch, a resistor and a capacitor. In testing, I found that I use the high gain switch setting almost all of the time and would hard wire any future radios to that position. There is a bit more background noise, but the clarity of a weak voice signal is better, in my opinion.

Building the 'Revised (Fairly) Simple SSB Rig' allowed me to tailor the final amplifier to be similar to the power output of the FT-817ND commercial radio. Steve's design for the 'Revised (Fairly) Simple' radio had a 25 watt amplifier, but I kept the 5 watt design from the original plans. The increased battery requirements for the amount of gain was not considered to be worth the extra effort. The power amplifier is built 'ugly' style on a piece of board attached to the radio case for heat sinking.



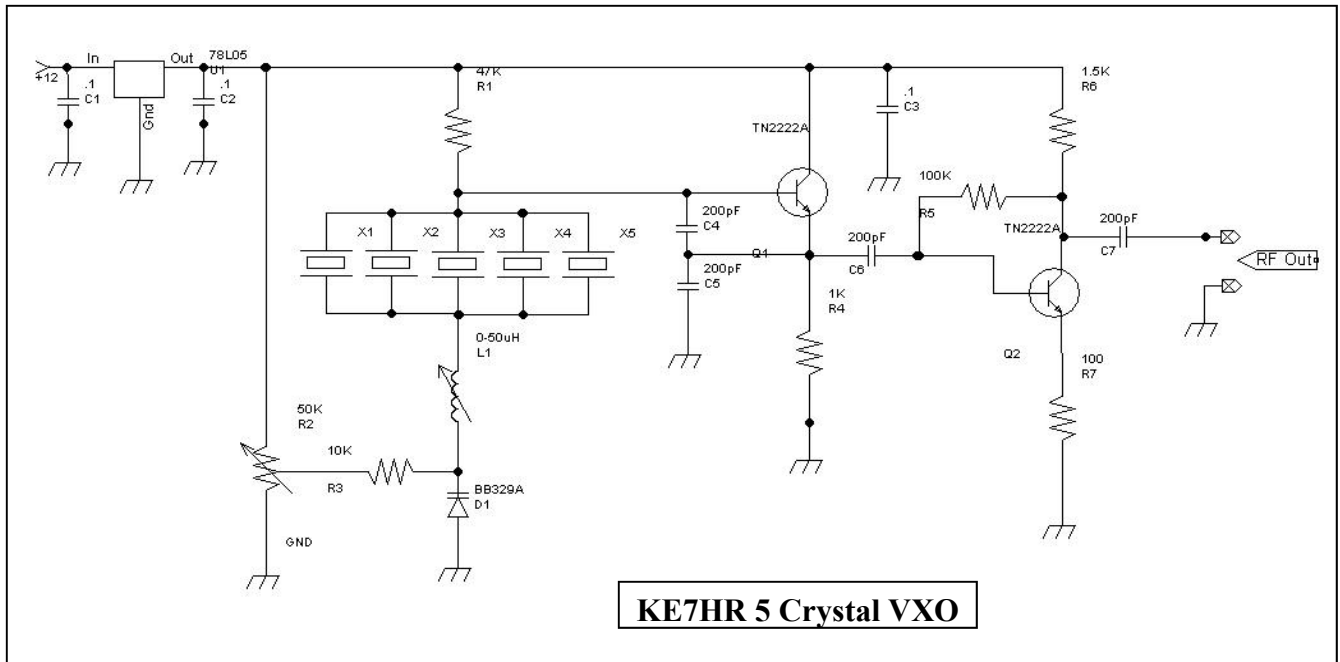
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The PTO VFO outlined in the original article worked great on the bench and in the ham shack. But, out in the field with temperature changes and other concerns there was some instability. I wanted to come up with a way to vary the frequency but still keep a steady frequency control, like crystal control. I had seen several designs that used a VXO or variable crystal oscillator. A VXO uses a variable element but still bases the frequency on the crystal. The normal variance of a VXO at the 5 MHz frequency that I needed was not much for a single crystal. Circuits were published on a 'Super VXO' that used two crystals to achieve greater frequency range. I wondered about extending that even further with more crystals. I found that the circuit was stable and had wider range with five crystals (where I stopped trying!). The package for the VXO was a mint tin, so my space was limited. I also wanted to have two variable channels, so that made for a total of ten crystals and the circuit board to fit into the small box. It works



very well. I have about 5 KHz of frequency range around two different frequency 'channels'. If there is interference the frequency can be shifted a bit or even changed to the other channel to have communications. The variable aspect of the VXO is rock solid and not so wide that a user can get far from where the other station expects! The schematic only shows one bank of crystals but there are really two switched banks to achieve the two 'channels'.



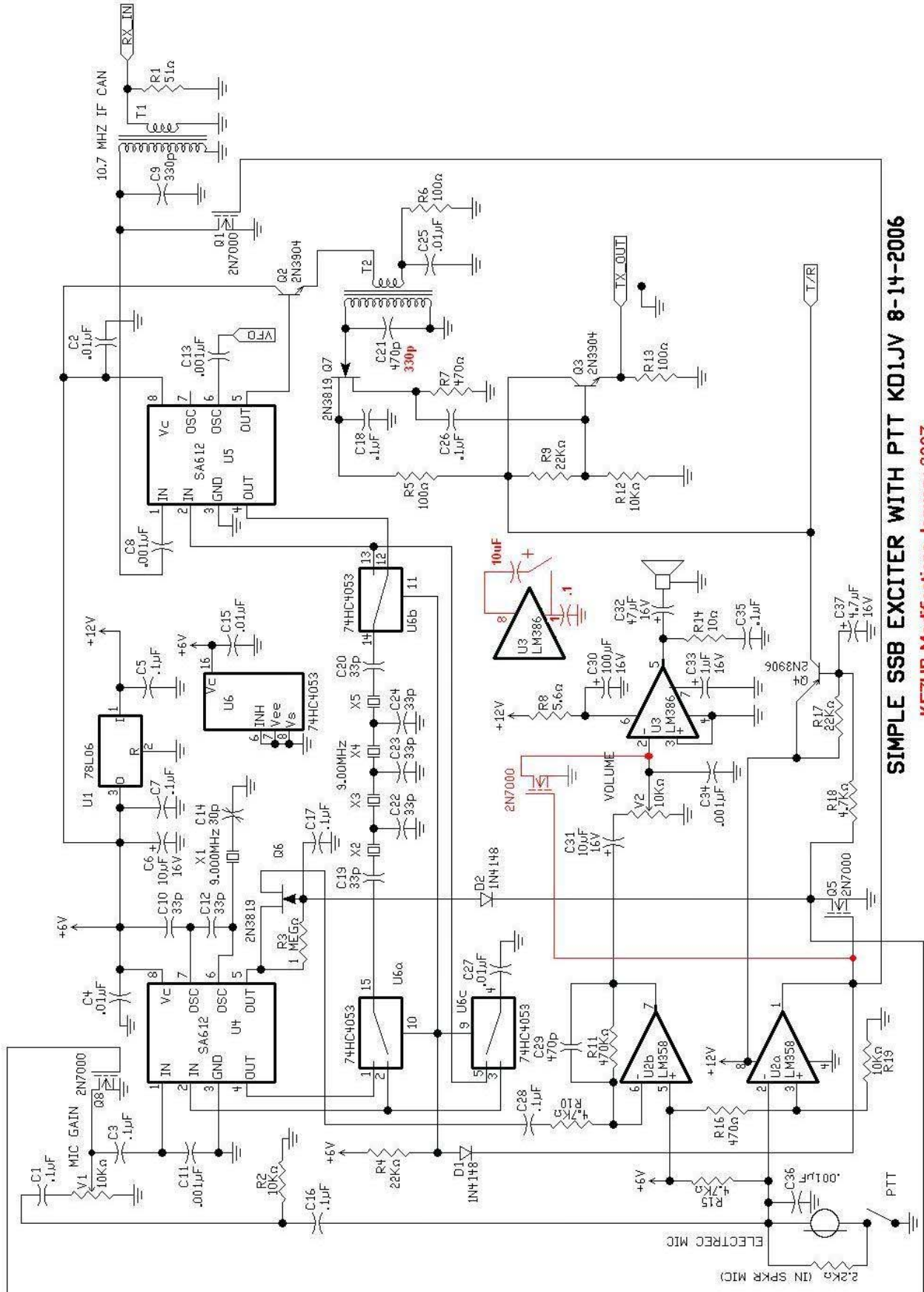
KE7HR 5 Crystal VXO

The whole radio is easy to use and readily reproducible. Because it is operating on Amateur Radio bands a valid General Class or above (USA) license is needed to operate. (The Morse Code requirements have now been removed from licensing so go take the tests!) The basic circuit layout for this radio may also lend itself to being shifted in frequency to the LF band around 185 KHz where other transverters and radios have been used in North America.

Performance of the SSB radio underground has been everything that I expected. The clarity of transmission and reception from deep underground raises eyebrows from those who have not heard it before. Contact between the DSB and SSB radios was fun! The additional complexity and cost of the SSB radio are made up for by its performance. The SSB radio project has become a kit currently available for the 7 MHz band and available from <http://www.qrpkits.com/> as the "MMR-40 Transceiver" for \$110. It should be easily modified to work on the 75 meter band. By the time a few additional items are added on (microphone VXO, etc.), the price for a functional, cave capable, radio should still be less than \$150.

For further expansion on the individual parts of the project see my Caver Radio website <http://members.cox.net/caveradioat/>.

(Continued on page 23)



SIMPLE SSB EXCITER WITH PTT KD1JV 8-14-2006

KE7HR Modifications January 2007

HF Radio at Grand Canyon Caverns

Paul R. Jorgenson KE7HR

The Fall 2006 Arizona Regional (ARA) meeting provided a nice, easy to access cave (elevator!) in which to use the ham radios for communicating with the surface. There was a dig going on at the end of one of the cave passages, at the deepest part of the cave. There was a generator at the surface for providing power to the hammer drill which was helping to move through the breakdown pile that has air coming from it. The radio was used to pass messages about the progress and to show that the commercially available (and homebrew) equipment was capable of being used in the environment.

Taking part in the radio communications were Stuart AC7FL, Ray KE7CPI, and Paul KE7HR. Assisting was Rich K7RRB and Gwen N7VAK. The requirement for the control operator of the HF transmitter is a General Class (USA) or above Amateur Radio License. The frequency we were using is in the 75 meter band or about 3.9 MHz.

We were able to have solid communications from the deepest part of the cave (about 220 feet below the surface) to the far side of the cave (about 500 feet away - all passages less than 1/2 wavelength high) and to the surface with low power - 5 watts. The radios used were two Yaesu FT-817ND transceivers, an Elecraft K2 (kit built), and my homebrew DSB radio. For antennas we used a random wire with a tuner, a MFJ commercial antenna, and my homebrew base loaded vertical with a tuner.

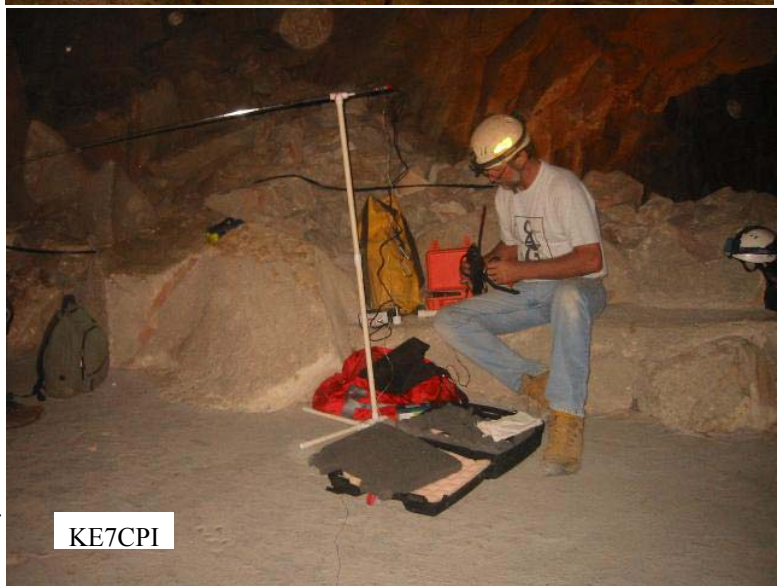
Our signal strength was so strong that we started turning the power down. The FT817-ND can go as low as 1/2 watt and the Elecraft K2 can turn down to 1/10 watt. Even at this power level we still had a signal strength of S8! 1/10 watt was less power than may of the headlamps that were being used on the project!

The rock is dry limestone and seems pretty transparent to the HF signal. We tried 2 meters VHF with 50 watts on the surface (Icom IC-229H) into a mobile whip, but the deep station could not hear the surface. The power feedline from the surface was apparently carrying some of the VHF to the cave and by standing right at the power drop a conversation could be carried on with the surface about 110 feet above. Further away from the power drop, even along the power line, there was not contact with the surface on VHF. We did have good VHF communications from one end of the cave to the other at 5 watts.

With such strong signals we decided to have a surface station walk away from the cave using the commercial MFJ antenna and a trailing counterpoise wire. With the power kicked all the way up to 5 watts, he was able to walk to a point that was nearly a mile away (4982 feet



KE7HR



KE7CPI

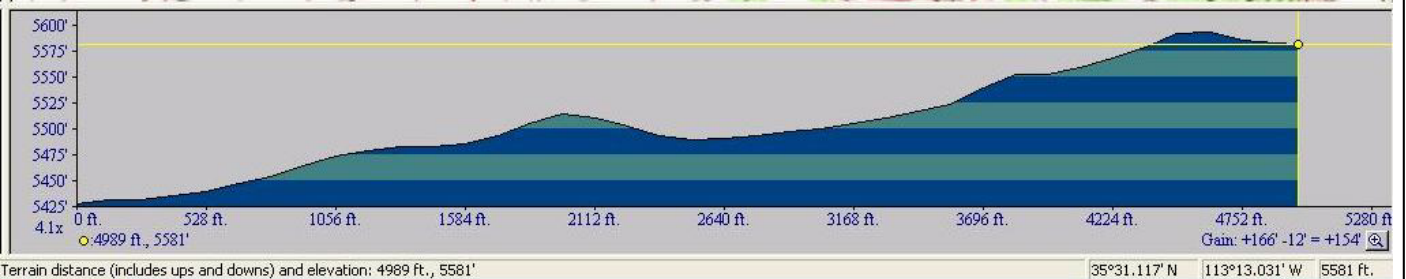
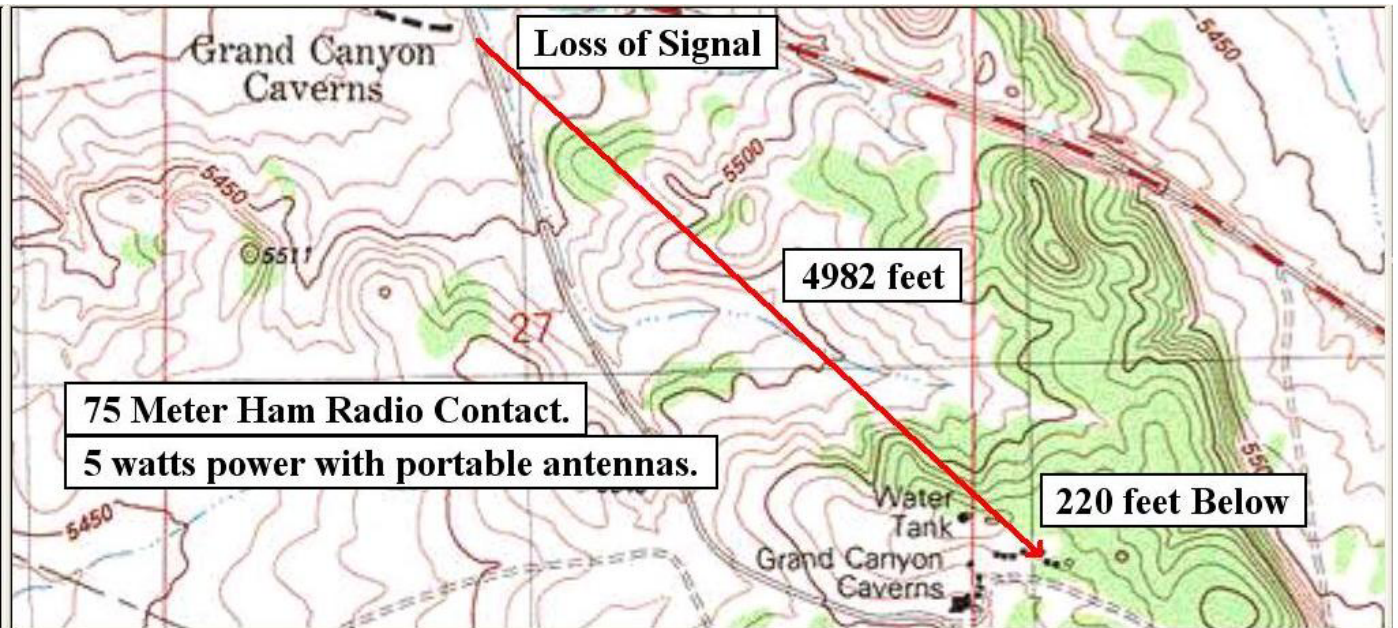


K7RRB

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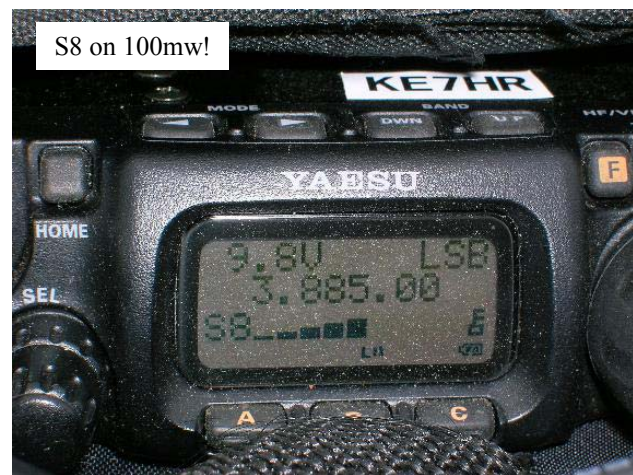
(Continued from page 24)

according to the map) before losing the underground signal due to power line noise. I could still hear the surface station clearly at the underground point! He was downhill from the entrance to the cave but was still about 50 feet higher in elevation than my underground point. No attempts were made to optimize the counterpoise (ground wire) alignment for best signal strength. We are getting outside of the 'near field' at nearly a mile of distance and nearly a whole wavelength underground! I am expecting that RF and not magnetic coupling is how the communications was done.



We also used the little DSB radio transceiver that I built to talk to the surface above the cave. It worked very well and was quite stable with its crystal oscillator. The assembled cavers (there were about 50 working on the dig) were impressed that I was communicating with the surface with a few parts that I assembled myself for about \$50. The big external speaker that I had hooked up made it easy for everyone in the room to hear the surface transmitter.

It was a successful day of talking through the rock. Coordination to start and stop the generator, bring tools, and find out that dinner was on the table made for a good day of caving. With such a simple system, cave communications may only be a ham radio license away!



C&E Section Minutes 2005

Brian Pease Secretary/Treasurer

Sunday 7/3/05:

The first C&E Section Field Day got underway as a small group of dedicated members carpooled from the NSS Convention campground site in Huntsville to Limrock Blowing Cave, owned by the Southeast Cave Conservancy. Doug Strait did all of the work to select this cave and allow access to more than the usual size group. He also did two radiolocations, one ~200 ft and a second ~500 ft from the entrance, with stakes in the cave and flagging above. The first was 76 ft deep and the second 87ft deep. Among the people who attended were Doug Strait, Paul Jorgenson, Jansen Cardy, Steve Stokowski, Willie Hunt, Brian Pease, Bart Rowlett, Ray Keeler, plus friends, spouses, and one dog. Bonnie Pease and others took pictures.

Willie Hunt demonstrated his Radiolocation gear, which operates on 325 Hz, a frequency that avoids both 50 and 60 Hz power line harmonics. His transmitter uses a MOSFET H-bridge driving a series-tuned air core loop about 12" in diameter with a crystal-controlled square wave. His receiver, also crystal-controlled, uses a 3-phase synchronous detector with CMOS switches and R-C filters, giving about 5 Hz bandwidth for quick nulling. Larger capacitors can be added to reduce noise. This is really a 6-pole commutating filter. For readouts, Willie uses three zero-center edge-mounted panel meters, which are centered when the signal is absent or nulled out. Offsets due to charge transfer by the CMOS switches are cancelled by summing differential (180 degree phase difference) outputs for each channel. The receiver is not phase-locked, but its frequency is set close enough to drift only about 1 cycle in ~30 seconds, slow enough to not degrade nulling accuracy. Gain control switches set the meter's motion to a reasonable rate. A separate, normal, meter on one channel indicates signal strength when the signal drifts into that channel. It all worked quite well. Willie was able to locate the surface mark over Doug's first Radiolocation with no problem.

Next, we tested my 185 kHz CB transverter voice radios with my 1/2" diameter by 12" long ferrite rod antennas. First we tested several LED lamps for EMI. Ray Cole's 24-LED light was worst (but a very good light despite this!), but even a tiny self-contained Princeton Tec light was pretty bad. All of the switching circuits caused some EMI. Flashes on cameras caused some noise, but an external flash unit was the king of EMI! Ray Cole manned a 185 kHz LSB station just beyond Doug's first Radiolocation, while I walked further in with Jansen carrying a 1 meter square loop. By this time (noon), the weather outside had some clouds with visible lightning, causing the ferrite antennas to become solidly atmospheric noise limited. Despite this, the range was good, perhaps 400 feet using an up-over-down path. We tried different orientations, with the best, as expected, being horizontal with the rods perpendicular to the signal path. Vertical coaxial was second place, with vertical rods third. Ray switched to the 1-meter loop, which brought the signals well up on both ends, along with the noise on his end. At ~500 ft distance I also switched to the 1 meter loop, and we both had S-9 signals on the CBs. We could have gone much further into the cave, but elected to come out. Willie Hunt and Doug Strait entered the cave with Willie's photo gear and giant strobes to take some big room pictures.

While we were testing 185 kHz gear,



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Paul Jorgenson set up his Yaesu FT-817 HF rig and homemade 80 meter base-loaded whip, which used a long coil of hookup wire on 1/2" OD PVC pipe with a ~5ft whip on top. The base had a ~50ft counterpoise of insulated copper wire stretched out away from the cave entrance. Bart Rowlett went into the cave and set up his FT-817 with a short mini-outbacker whip with a counterpoise wire. They had good 80 meter voice comms all the way from the entrance to Doug's second Radiolocation point at ~500 ft range.



Lastly, I entered the cave with Ray Cole to do some 80 meter dipole tests. At 500 ft range, I had no trouble talking to Paul with my MFJ dipole horizontal and pointed at him, so we tried some antenna orientation tests. Signals nulled when my dipole was perpendicular to him, and seemed better when I turned it close to vertical. I changed it to an "L" antenna. This gave the strongest signals of all,

when the horizontal portion of the "L" was pointed at Paul, weaker when perpendicular, and a shallow null when pointed away from him! Based on this, I had Paul swing his counterpoise to point toward us. His signals rose from S7 to S8! Ray & I moved much further into the cave, to the "breakdown" ~1000 ft from the entrance. At this point we could not hear even a crackle of atmospheric noise, so we obviously were quite deep, or under a conductive layer. I found that I was hearing a little bit of EMI from the IC-703, which was being conducted on the outside of the coax. The L or dipole configuration made no difference. This antenna is direct-driven without a link. Ray's 24 LED lamp made really serious EMI. We were too far away for Paul to hear us, especially given all the atmospheric noise at the entrance. It is possible we could have heard him.

It never did rain, and a good time was had by all.

Monday 7/4/05:

Attendance:

41 people signed in for 2005 compared with 37 last year. We now have a total of 99 "members" who have signed in within the last 5 years, with 20 known hams.

The luncheon and chat session was 12-2 PM. We did not have the business meeting during this time due to the way the schedule was written. We talked about Field Day. We discussed the interference to Cave Radio Communications from the switching regulators in LED lights; propagation paths (up-over-down vs. straight through the rock); the increase in conductivity and permittivity with frequency, etc.

At 2 PM, Bart Rowlett called the meeting to order. I read the 2004 minutes, which were accepted, and gave the treasurer' report. There has been no income (except interest) or expenses since the last report. The bill for NSS web space has not showed up yet. The account held \$1520.05 as of 5/30/05, compared to \$1512.28 last year.

Old Business:

Gary Bush has been doing a great job with the website, which is now up to date with every issue of Speleonics through #25.

Paul Jorgenson continues to do a superb job with Speleonics. The web issues look very professional with lots of color.

Bart talked about the Field Day at Limrock Blowing Cave, and said that it went well.

New Business:

Paul Jorgenson said that he was familiar with the Bellingham, WA area, and would coordinate finding a Field Day site at a lava tube cave or mine. Possible projects: Measurement of the light output and/or light patterns of LED lamps (Doug Strait). This could also be done in a darkened room. One way to do this is with a digital camera and a computer program, but the camera response does not exactly match the human eye. Magnetic compass errors in lava tubes. Bart said he has a gyrocompass. This could also be done on the surface of a lava field.

There were a couple of thoughts for section projects:

The BOG needs a voting machine.

A digital camera slave flash. (Dave Gibson has done one.)

Elections:

Bart called for elections. Skip Withrow ran them. All 4 of last year's officers were nominated un-opposed, and re-elected by show of hands. They are:

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Bart Rowlett for Chair

Brian Pease for Secretary/Treasurer

Gary Bush for Communications Chair

Paul Jorgenson for Publications Chair

Presentations:

Paul Jorgenson ran his short video/sound clip showing interference to 185 kHz reception by different LED lamps with switching regulators.

Paul showed two portable antennas for the 80 meter ham band. The first was an MFJ 1899T multi-band telescoping whip, about 5 ft long, with 50 feet of speaker wire as a counterpoise, which was connected to the shell of the antenna connector, not to the radio, to reduce RF feedback. The antenna could be mounted vertically or horizontally. He had a homemade manual tuner in-line that was not really needed.

The second was a homemade base-loaded telescoping vertical whip about 8 ft long. He used #22 solid insulated wire wound on ½" ID PVC pipe. This antenna is longer than the MFJ, has a larger loading coil, and worked better in tests when the same 50 ft counterpoise was used. This was the antenna that was used during the Section Field Day to good effect.

Paul also showed a small 185 kHz ferrite rod antenna that he made by assembling 9 small rods into 3 stacks of 3 in a PVC pipe, then winding on the pipe, tuning, and matching.

Brian Pease gave his paper "Optimizing Circuits Using Computer Simulator", which described using a free Spice circuit simulator program to model and optimize three 3496 Hz beacon circuits. This is much easier than breadboarding actual circuits.

Ray Cole talked about "Picaxe" microcontrollers. www.picaxe.com. These are preprogrammed Microchip programmable ICs with built-in basic language and built-in serial port interface. No hardware programmer is required. Some versions have built-in PWM, A/D and D/A, audio tones, etc. It is used by students. There are many websites. Parts and app notes at www.phanderson.com, who also sells on eBay.

Ray also mentioned Underwater Kinetics, www.uwkinetics.com, who make UK or UKe dive lights, as a source for rugged, reliable LED lights with real switching regulators.

C&E Section Minutes 2005

Brian Pease Secretary/Treasurer

8/7/06

Attendance:

49 people signed in for 2006 compared with 41 last year. We now have a total of 118 "members" who have signed in within the last 5 years, with 20 known hams. Starting next year, members who have not attended since 2002 will be dropped. This is just a book-keeping exercise for the NSS.

Secretary/Treasurers Report:

Lunch was held in Bond Hall RM 105 from 12-1 PM. The short meeting started at 1 PM. Brian reported that there was no income or expenses during the past year. Last year, on 5/30/05 we had \$1520.05 in our account at Peoples Bank in CT. This year, on 6/19/06 we had \$1530.77. Brian gave last year's Minutes (on screen), which were approved.

Business:

Bart Rowlett asked about having the business meeting during the Section Lunch rather than at the beginning of the Session. There seemed to be general agreement to do this. Bart made a formal motion to have the business meeting during the Section Lunch at future conventions, which was unanimously approved.

Bart asked if anyone knew of any caves near next year's NSS Convention site in Indiana that the section could use for a field day. Marango Caverns (commercial), and a quarry were mentioned.

Gary Bush has the Section Website completely up to date. The URL is <http://www.caves.org/section/commelect>.

The current officers were re-elected as a group unanimously.

They are:

Bart Rowlett, Executive Chair

Brian Pease, Secretary/Treasurer Chair

Paul Jorgenson, Publications Chair

Gary Bush, Communications Chair



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Session:

Brian Pease gave a short talk describing the Princeton Tec LED *Apex* headlamp. He showed plots of power consumption versus battery voltage for each of the 4 modes of operation. He showed why the lamp is ideal for use with rechargeable NiMH AA cells, and why it makes a nearly ideal primary caving headlamp, with few drawbacks.

Brian also gave a brief talk describing several computer programs that work with sound cards to turn a laptop computer into a sophisticated audio frequency receiver or even into a complete text transmitter/receiver requiring only amplifiers and an antenna to form a complete 2-way Thru-the-Earth radio. The programs included *Winrad*, *SD Radio*, *Spectrum Lab*, *Stream*, *Hamscope*, and *Jason*.

Ray Cole gave his talk on doing several radiolocations in Memorial Day Cave in West VA with Phillip Ballister during a February snowstorm. Ray used gear of his own design for some locations. For deeper locations, Ray used his large transmit loop along with Phil's version of Brian's "DQ" radiolocation receiver.

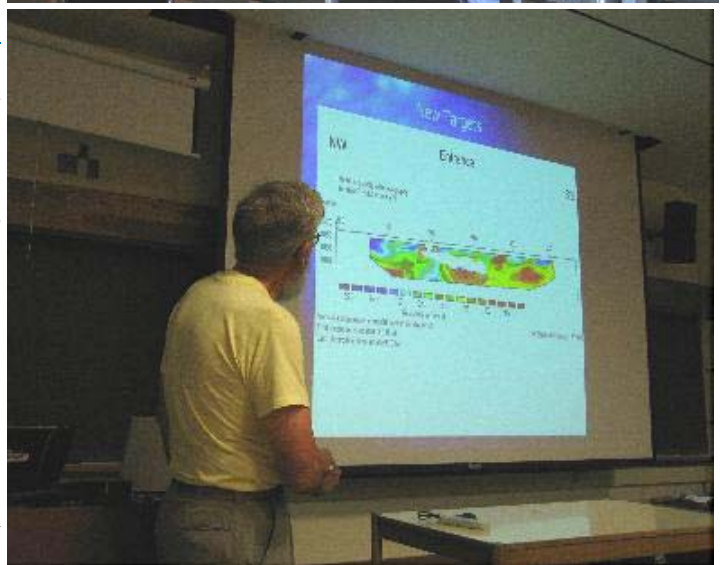
Ray also talked about his support of a dogsled trip to the north pole by Prince Albert II of Monaco. They decided to use the Iridium satellite telephone system, which has 66 satellites 485 miles high. Iridium relays signals from one satellite to another until a ground station is reached, which allows it to cover the entire surface of the Earth. Another satellite scheme requires one satellite to be in view of both the user and a ground station at the same time. There are satellites that will store small amounts of data until it moves into view of a ground station. And then there are the geosynchronous satellites that are close to the horizon for users in Polar Regions. Iridium is mainly a voice bandwidth service, but can transfer 2400 bps/channel. Four channels were used to send still photos and video clips along with voice, weather data, and 24-hour communications. They also put a tracker on one dogsled for real-time tracking. See <http://www.monaco.arctic-expedition.mc>.

After the break, Paul Jorgenson, KE7HR, described his 75 meter DSB transceiver. He chose the VE7GC Wee Willy 75 meter DSB transceiver project which is DSB transmit & SSB receive. See <http://www.qrp.pops.net/willy.htm>. He changed the transmitter circuit from 6V to 12V, which boosted power to 2 watts output. He used a VFO he had on hand. He plans to build the KD1JV Simple SSB Rig with PTT, which has electronic switching – a neat circuit with a published PCB layout. The BITX design from India is an SSB design with many discrete transistors. WA7JHZ also has an SSB design, but it uses complex mechanical T/R switching.

Paul also showed his message keyer, which is an ID-OMATIC kit for ~\$20.00.

He also showed his APRS (Automatic Packet Reporting System), which consisted of a GPS, and adapter box, and a 2-meter handheld. The signal is relayed by a store-and-forward digipeater to users who can then track his location.

John McLean described his equipment for measuring Earth resistivity using a multi-electrode array. He injects a constant DC current through one pair of electrodes, flipping polarity regularly to avoid electrode "polarization". He uses 150 VDC at ~40mA. He measures the voltage across a second pair of electrodes with a DVM that can be interfaced with a computer. The entire process is controlled by an old computer, which selects the electrodes, injects the current, flips polarity, records the voltage, and stores the data. The process takes about 35 minutes for one line of electrodes. The speed is limited by the settling time of the



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DVM. He typically uses 6 inch copper plated steel electrodes, with a cup of saltwater in dry areas. A copper foil lined pit with saltwater makes excellent contact. He has run more than 40 lines in 5 different areas, many over Fort Stanton Cave, NM, which is a large shallow cave.

John has used a demo version of a post-processing program to reduce the resistivity data, but currently is sending the data to a Professor for analysis. The result is a very nice 2-dimensional cross-section of the area below the electrodes. There will soon be public domain software available. His results look similar to commercial resistivity equipment that is extremely expensive. He has successfully imaged passages near the Big Manhole dig in NM, to help direct the dig.

John Lyles showed a tiny Audiovox PVR-100 video recorder that he purchased on Ebay. It stores highly compressed video in Secure Digital (SD) memory cards. He used it to record the output of thermal imaging cameras which he experimented with for cave entrance detection, with mixed results.

John also showed the new very small Leica Disto A3 rangefinder. It fits in a Pelican 1030 box. It is the first Disto to use all-electronic instead of mechanical self-calibration. For cavers, it shows the last 3 readings simultaneously. He purchased his for \$285.00 with the box (a special deal for cavers) from Mark Kliever at laserstreet.com.

John found a Keystone holder for the 3V 123 lithium cell at Mouser. He mounted two holders in a tiny Hammond aluminum box, with the fasteners replaced by cap screws with O-rings.

John also showed ferrite and bicycle wheel beacon antennas as well as a compact (perhaps too compact!) version of Brian's DQ beacon receiver in a Hammond aluminum box, with built-in 9 Volt batteries.

David Larson showed his "Canary" oxygen meter (yes it is yellow!) which features a replaceable sensor and a lithium battery. He commented on the use of this meter in Chapat Cave in Belize, where oxygen levels can dip below 17%. He said that the CO2 levels did not seem to be as high as expected for this much oxygen loss.

David also showed his Sten headlamp with two high-power LEDs, one broad and one narrow beam. It is beautifully built, but the switch on the headpiece has an unshielded magnet which makes the lamp unusable with a compass.

He also commented that red LEDs do not irritate bees in the way white LEDs do, because bees are sensitive to the ultraviolet end of the spectrum.

David also asked about interest in single wire telephones and what people would pay for one, kit or assembled. He estimated \$50 for a kit and \$100 assembled. There is apparently not enough demand right now. He also mentioned the use of small aluminum wire on a self-feeding reel.

Lighting Session: On Friday, 8/11/07, a meeting was held to discuss how to compare caving headlamps with actual measurements. Bart Rowlett gave a brief talk on lighting principles. He said that traditionally, MSCP (total light output), continuous run time, bulb life, reflector efficiency, patterns, and focus were assessed subjectively. He said that inexpensive photometers are now available for <\$100.00 with .01 Lux resolution and a serial data output for life studies.

Bart said that subjective criteria should be defined, including:

Total luminous output (Lm) within a specified field, such as a 30 degree circle.

Luminous intensity at beam center

Power consumption (easy)

Operating life (easy)



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Exit pupil area – mud resistance

Color temperature

Beam uniformity

Measurements repeated at the different settings

Comments:

A photo of the beam illuminating a standard target is useful, but different cameras will give different looking results.

Luxeon gives full beam patterns for there LEDs, which is the ultimate info.

Beam measurements need to be made over as much as 90 degrees.

The sharpness of the cutoff of light at the beam edges is important. Many people prefer a gradual cutoff similar to carbide lights.

With LEDs, operating life is subjective because the light usually drops off gradually as the battery voltage drops, with weak light available many hours (or days!) after the usual bright light is gone.

The Lumen (Lm) is equivalent to the Watt, but takes the human daylight eye response into account.

Lux (Lm/mtr squared) is the unit of illuminance. This is what we want to measure.

The Candela (Lm/Steradian) is also called candlepower, formerly Luminous Intensity. There are 4pi steradians in a sphere.

MSCP (Mean Spherical Candlepower) has fallen into disuse.

Demonstrations:

Bart set up his photometer on the blackboard, and a many different lights were measured at the center of the beam and entered into an excel spreadsheet.

Editor Notes:

The Internet URL addresses and email addresses are always moving targets in the electronic world of today. The URL and email addresses are believed to be accurate as of the printing date. If you find an address that is no longer valid, try doing a search for the author or specific subject. Many of the authors are NSS members and are in the Members Manual, which is issued yearly.

I wish to thank those that have taken the time and effort to write up their projects so that we may all share in those efforts and benefit from them. I know that there are more of you out there reading this that have cave related communications or electronics projects that would benefit the caving community as a whole. Please take the time to write up your project (plain text is fine - photos are a bonus) and have it published so that the caving community can share in your innovative solutions. Email the Editor (whoever that might be) and discuss your project for publication.

This is my fifth issue as Editor and if you don't want to see it become Paul's notebook, write up an article! If you have any desire to become the Editor, please let me know or any other Officer of the Communications and Electronics Section.

Paul R. Jorgenson KE7HR NSS39382FE - ke7hr@cox.net