speleonics 4

SPRING 1986

CONTENTS

Charles Bishop operates cave radio over Blue Springs Cave, Indiana, 1976.

SPELEONICS 4

Volume I, No. 4, Winter/Spring 1985-86

SPELEONICS is the quarterly newsletter of the Electronics and Communications Section of the National Speleological Society. Primary interests include cave radio, underground communications and instrumentation, and cave-related applications of amateur radio. Membership is unrestricted (NSS membership not required). Membership, which includes four issues of SPELEONICS, is $4.00 in USA/Canada, $6.00 elsewhere. Send subscriptions to section treasurer **Joe Giddens** at the address below.

Complimentary copies of SPELEONICS are mailed to NSS offices and sections, the U.S. Bureau of Mines, U.S. Geological Survey, and the Longwave Club of America.

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Editorial:

Entranceless Caves

Conservation-minded cavers have charged that our generation seems determined to deplete the limited natural resource of virgin cave. The rate at which entranceless caves are accidentally discovered suggests, however, that these could be the rule rather than the exception, and that cavers may literally have only scratched the surface! Rane Curl's statistical study (NSS Bulletin, November 1958) theorizes that entranceless caves are numerous but very short (because long caves have greater probability of forming entrances). Indiana's two longest caves (20+ miles each) were entranceless until natural collapses opened them in the 1950's.

Electronics-based geophysical technology has dramatically increased estimates of the world's oil reserves, and might do likewise for caves. Future cavers may depend heavily upon electronics for finding new caves.

Seismic, gravity, magnetic, resistivity and radio-frequency measurements have been used to detect underground voids. Most of these techniques indicate only vague probabilities, and are reminiscent of the blind men and the elephant.

Cave radio neatly bypassed the problems of using conventional survey to locate artificial cave entrances. Practical void-space detection will require an analogous breakthrough. A "Cave Scope" giving us Superman-like "X-ray vision" would have obvious mining and military applications, and in the wrong hands...?

Suppose we could "make the earth transparent!" Imagine the hysterical letters to the editor of the NSS News from what we shall benignly call purists, bemoaning the imminent death of caving (as they know it)!

Cosmic rays have been used to "x-ray" the Egyptian pyramids, looking for secret chambers. The process is tedious. Neutral muons can penetrate thousands of feet of earth; perhaps something analogous to CAT scanning, using a muon source on one side of a ridge, and a movable detector, would work. (But remember that all this must be either affordable by cavers or borrowable from the local university!)

Undetailed articles about underground radar have appeared in electronics trade journals. The Army Corps of Engineers is reportedly working on electronic void-space detection at their experiment station at Vicksburg, Mississippi, using seismic, resistivity and radar techniques. Electronic sensors are rumored to have detected tunnels under the Korean "demilitarized" zone. Defense Electronics and Aviation Week magazines hint that orbital radar can see submarines and large tunnels. Infrared photography from space can detect the presence or absence of attic insulation in a single-family house (Scientific American, September, 1985). Airborne synthetic-aperture radar can look through vegetation to the bedrock. Omni magazine (9-85, p. 64) says, "Four or five promising nonacoustic methods for detecting submerged submarines are now being researched." The same Omni contains an article on dowsing, which we shall not discuss at this time.

Large karst features are visible, with difficulty, on Landsat photos. If spy satellites can read license plates from space, what else can they see? Will such information become available to the public as newer technologies replace present systems? Commercially-valuable spinoffs of secret technologies eventually reach the market. Electronic sensors used in the Vietnam war have been adapted to oil exploration. Infrared Ektachrome color film was top secret during the war, where it was used for detecting camoflage.

"Anything is possible if you pour enough money into it." A modern myth? Perhaps the "Star Wars" program will tell. Research in remote-sensing (which includes detection of submarines and oil) enjoys virtually unlimited funding. Some of these technologies are probably adaptable to cave detection. Cavers employed in the geophysics and aerospace industries should be vigilant for applicable methods.

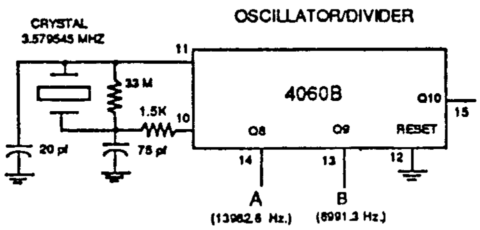
What next? Remember the Warner Brothers' cartoon about portable holes? Now, there's a useful

CORRECTION

Dear Frank,

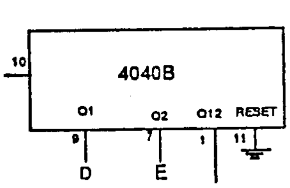
I have constructed the "ORGAN CAVE RADIO" presented in vol. 1 no. 3 of Speleonics (FALL 1985) and was very pleased with results. There were, however, some typographical errors in the published schematic diagram (circuit Fig. 3, pg. 5) which should be called to the attention of readers. These are listed below:

1. The 3.58 MHz crystal is shown with a short circuit across it. This can be corrected by removing the line between the top of the 20 pf capacitor and the bottom of the crystal as shown below.

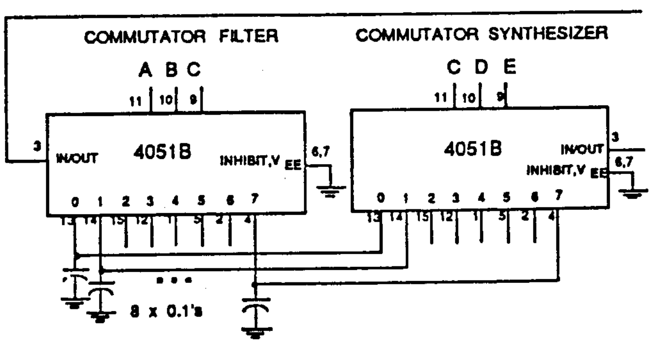


2. The "RESET" pin of the 4040B divider IC is shown as pin 12. This should, instead, be pin 11 as indicated below.

DIVIDER



3. The schematic diagram needs to indicate connections for pin 7 (V_{EE}) of the two 4051B IC's. This is the signal reference and must be at a level $\leq V_{SS}$ (the control input supply reference). I chose to connect pin 7 to ground return and this worked fine (see below).



4. The "0" label is missing from pin 13 of the left hand 4051B IC.

Please include a list of these corrections in the next issue of Speleonics and advise me if there are any questions. Thanks.

Sincerely,

James J. Wolford, WB8FAX
5839 North Oakland Ave.
Indianapolis, IN 46220

(note: Ray Cole concurs with these corrections; the diagrams are from Ray's corrected schematic.) --FR

LETTERS

Westminster Spelaeological Group
Chairman - P. J. Hart,
42 Gravel Hill,
Addington,
Croydon,
Surrey. CRO 5BD. England.
tel 01-656-9054
14 July 1985

Dear Joe,

Thanks for forwarding volume 1 no. 1 of Speleonics. I enclose an international money order for $4 for the year's sub. Unfortunately, commission on the I.M.O. amounts to nearly $3 so this is an expensive way of paying. Any suggestions?

[Ed. note: Send U.S. cash.]

Perhaps a few words about myself. I designed and built a v.l.f. underground radio in 1975/76 using u.s.b. operating at a frequency of 120.37 kHz. The transmitter produced about 10 watts p.e.p. and a 70 turn loop antenna 28 inches square was used. Speech and pulsed tone facilities were provided and the best range achieved to date was about 550 feet on 2 way speech. The limit on performance was generally reception at the surface due to interference from other users around this frequency. After a period monitoring the v.l.f. spectrum using a communications receiver, I changed frequency to 125 kHz l.s.b. However, interference is still a problem sometimes. The v.l.f. band is quite crowded in Europe. In 1978 I scribbled out the circuits and some constructional details for a couple of friends and since then until recently did no more work on them. Apparently, the circuits found their way to Canada where Ian Drummond and Julian Coward copied them and put much work into refining and improving the design. A chance letter from Ian about a year ago fired me with renewed enthusiasm and I am now constructing some hand portable units.

Apart from caving, my other main interest is Ham Radio - callsign G3SJX. I have 400 watts of s.s.b. on the h.f. bands, dipoles and quad loops for 80 and 40m and a 3 element triband beam for 20/15/10m as well as v.h.f. gear. My main interest in amateur radio is working dx and contests. I am on several committees of the Radio Society of Great Britain and regularly publish articles and equipment reviews in the Journal Radio Communication. I understand from Speleonics that there are a number of licensed amateurs in the group. How about a weekly or monthly net? If a suitable frequency/time is chosen to allow transatlantic working, I would like to join in as well. I suggest a frequency at the top end of 20 metres in the range 14300 - 14350, possibly 14325 kHz.

Another project I have been involved with may be of interest. In 1979, the Westminster Speleological Group organised an expedition to the Astraka Plateau in Greece to descend some of the known shafts and search for new discoveries. Epos Chasm was planned with Provetina a possibility. In order to provide reliable communication on some of the larger pitches, I experimented with a guided wire communication system. Two 27 MHz low power c.b. walkie talkies were used (illegal at that time in England) and a single guide wire. Initial experiments in some of the Yorkshire caves in England were reasonably successful even in some horizontal caves where the wire trailed along a streamway. In Greece, the system worked extremely well. The dry shafts gave considerably reduced attenuation compared with the comparatively wet Yorkshire systems and communication was easily achieved from the surface to the bottom of Epos Chasm (1450 ft deep). It proved indispensable on the big 600 ft penultimate pitch. A thin guide wire was run through the system. Communication could be achieved at any point by bringing the antenna of the walkie talkie in close proximity to the guide wire. Communication on the move was possible. I have done no other tests on this guided wire system but I am sure that further refinement would prove invaluable. The system is more flexible than a telephone, allowing communication on the move, requiring only one lightweight conductor, and allowing several simultaneous conversations if different frequencies are used. The range is greater than is achievable using v.l.f. radio particularly in dry systems.

Once again thank you for putting me on the Speleonics mailing list, I look forward to receiving future issues.

Best Wishes,

Pete Hart

***

Dear Mr. Giddens,

I have appreciated the last 3 issues of Speleonics and wish to continue to receive this excellent publication. Please find enclosed monies for my subscription ($6) U.S.

My interest in speleology is 'cave diving' in particular in the caves of the 'Nullarbor.' I have a working RDF and the unit has been used to determine the relative location on the surface of major air spaces (i.e. where divers can climb out of the water onto dry floor) and as an aid to surveying the cave. Recently (1983) a 2 way voice communication system was developed and used successfully on our Australian 'Cocklebiddy Cave' expedition.

I enclose a paper I presented at an A.S.F (Aust. Speleological Federation) conference held in Australia during December 1984 on this communications system.

I emphasise that the system was developed without any field test and worked with excellent clarity. I wish to further develop the same system with smaller aerials however I find research time limiting and would appreciate a 'forum' on this topic i.e. use of voice frequency with large diameter aerials.

Yours sincerely,

Ron Allum
63 Hancock Road
South Australia 5091

[Ron's circuit features an original and elegant solution to the problems of oscillator stability and precise antenna tuning!] -- F.R.

***

Dear Frank,

#3 issue of SPELEONICS arrived a few weeks ago. The Slug Tuned Coil came out great. All interesting stuff. It is so refreshing to see some practical applications.

It occurs to me that part of the problem (a big part perhaps) in using cave radio is finding people who are fluent in CW (Morse code); able to use it both conversationally and formally. If it IS a problem I have no answers except creative propaganda and training programs that are both fun and effective. Practice til the conversational level is achieved, where it won't be forgotten even under stress.

73,

Mike Mideke
Box 123
San Simeon, CA 93452

[Mike publishes a newsletter for low-frequency enthusiasts, <u>1750 METERS: WESTERN UPDATE</u>, available for large SASE's.]

***

Dear Joe

I have checked, and I can not provide any significant bibliographic items on cave radios beyond what has appeared in <u>Speleonics</u> so far. I guess this is not surprising, since I provided much of the bibliography for Charlie Bishop's 1976 report to MCNP, which has itself served as a reference since then. And I don't have enough to write about early cave radios to get me inspired about doing so.

However, you might like to print the enclosed article. It was printed in <u>Compass & Tape</u>, volume 2 number 2 (fall 1984). I am sending a copy of the original ms, because the editor of <u>C&T</u> introduced some errors when he printed it. I'm sure it would be interesting to electronics people, and they are the ones most likely to rise to the bait and try to construct such a thing. If you do run the item, be sure to acknowledge its previous appearance.

Looking forward to next issue.

Good caving

Bill Mixon
7413 Grover Avenue
Austin, Texas 78757

STRANGE CALLSIGNS

Dear Sirs:

Does the government authority issue permits for underground wireless stations or do you chaps have your own system of strange callsigns beginning with "NSS?"

Oliver Lindenbrook
Edinburgh, Scotland

Dear Oliver,

By international agreement, radio callsigns in the United States may begin with the letters A, K, N or W. The N prefix is used by civil aircraft, some hams, and the U.S. Navy. The Navy operates stations NSS (shortwave), NAA (VLF), and others.

None of these N-calls are related to cave radio-- There are no government restrictions on wireless communications below 10 kHz, nor have cave radio operators found it necessary to adopt callsigns. The National Speleological Society (NSS) issues consecutive membership numbers (currently in the 27000 range), creating an illusion that its current constituency is larger than is actually the case. Like a radio callsign, the NSS Number is useful for looking up someone's address (in the annually-published membership list), and indicates roughly the time of initial affiliation. A low number is considered a status symbol or an inverse index of gullibility, depending upon one's perspective. The optional alphabetic suffix designates class of membership and/or mutual-admiration awards, e.g., RF means "Regular Fellow." (No kidding! With some cavers it's necessary to point out such things.)

YOU, TOO, CAN HAVE AN NSS NUMBER! Annual dues for Regular membership are $22.50, for which you receive the monthly NSS News, the occasional NSS Bulletin scientific journal, and opportunities for good fellowship and new friends. For more information and membership applications, write to

National Speleological Society
Cave Avenue
Huntsville, Alabama 35810
USA

INVENTIONS FROM AUSTRIA

An ancient burglary tool rediscovered, and a circuit which automatically connects a spare light-bulb when the primary bulb burns out, come to us from Austrian caver **Peter Ludwig**.

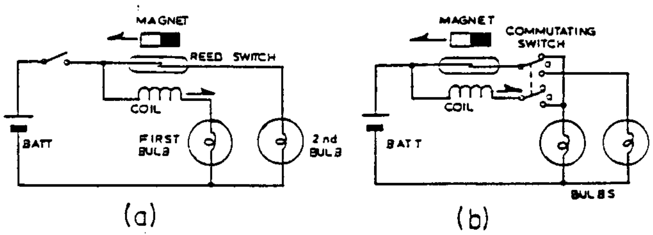
In SPELEONICS 1, we promised to occasionally publish descriptions of especially appealing nonelectronic devices. **Bill Eidson,** who spent a year in Austria, told me about Peter Ludwig's ladder. I sent Peter some back-issues and asked for his plans and permission to publish them in the USA. Besides being especially interested in cave-related electronics, Peter is a cave diver, parachutist, and licensed underwater blaster. He sent lots of interesting information, and asks the best way to send his Electronics Section membership dues. [$6 outside USA/Canada. International money orders are expensive; perhaps the best way is to send U.S. cash to our trusted treasurer, Joe Giddens.] The ladder-pole does have electronic applications; it would be invaluable for erecting antennas on ham radio Field Day!

Peter writes, "The 3.579545-MHz crystal is available in Europe... I learned your 'emergency bulb repair' many years ago from some old people who did this with 110v bulbs because they were very rare... Your strange method of numbering wire sizes is completely unknown in Europe but I got the diameters from Ian Drummond's antenna design program... I want to make some cheap (5 bucks) blasting machines from electronic flashes; they are very small and work with a AA-cell. Maybe I'll make a safe tester circuit in the same box, cigarette-pack sized... Thanks for the 'Caver of Fortune' magazine...We have government-licensed cave guides (I'm one of them) and this helps us much on private territory."

SIMPLE CIRCUIT FOR AUTOMATIC SECOND BULB

Peter Ludwig

A magnetic reed switch is closed by a permanent magnet. The current for the first bulb flows through a coil with a few turns (determined empirically, depending on current, magnet and switch). The polarity of the coil is such that its magnetic field opposes that of the permanent magnet; the switch is held open as long as current flows through the first bulb. When the first bulb burns out, the magnet closes the reed switch and turns on the second bulb.



(a) The magnet is glued to the reed-switch and the coil (usually 10-20 turns) is wrapped around. (b) Commutating switch selects either bulb for primary or spare.

THE UNIQUE SELF-CLIMBING LADDER

Peter Ludwig
Gföllnerstrasse 6
A-4020 Linz, Austria

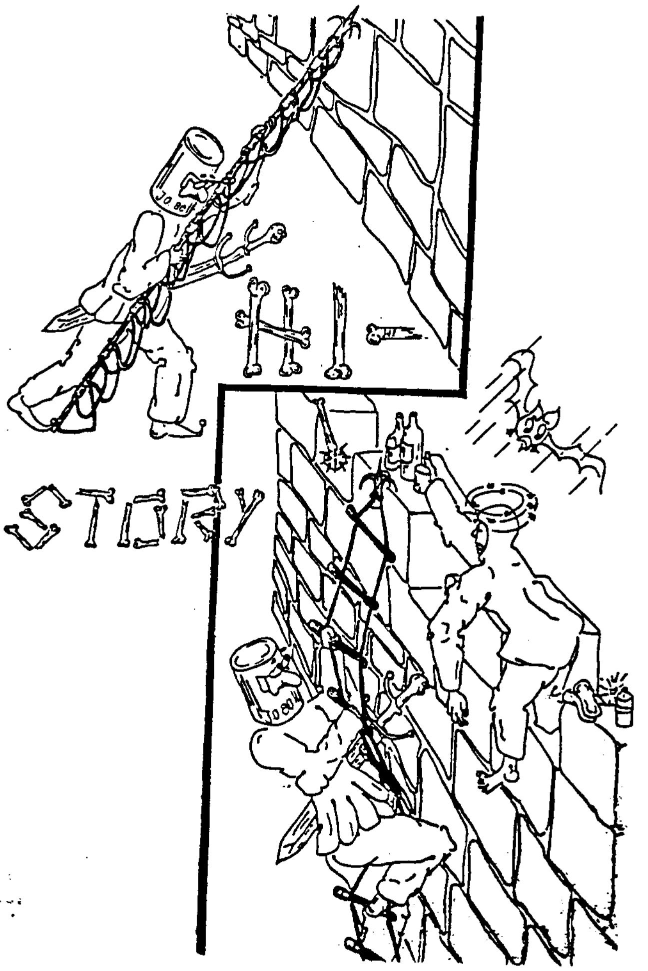
The steps make a pole, so it is possible to reach a higher point and attach the top there. Afterward, the ladder is separated and used in conventional fashion.

As you can see in the pictures, the self-climbing rope ladder was used long times ago. It was used for stealing alcohol; the result was that knights were excommunicated for using the ladder, so the ingenious system was forgotten until a caver met the ghost of one of the medieval knights and bought the patent for some gallons of holy water (and some of beer too). The ghost was met in a secret passage under an old castle and is still living there because meeting cavers is more fun than being delivered.

Construction: The ladder has 16 steps. Eight of them are made from 20x20 mm square aluminum tubing, 2 mm wall thickness. The other 8 are from 15x15 mm tubing with 1.5 mm wall thickness. Every step is 25 cm long and has two holes, 5 cm from each end, for the cable. The top-part is 20 cm long and is made from the thicker tube. It has a strong hook made from a carpenter's hook. The top-part is attached to the ladder with a 50 mm "Maillon Rapide" screwing chain-link. The ladder is connected directly to the hook to avoid one unnecessary link. The hook is attached to the top part with screws. An alternative to the hook is a sling made from tubular webbing, also attached with the Maillon Rapide. The webbing is 1/2" wide and inside (trick!) has a 1.5 mm^2 copper wire. This wire makes the loop hold its shape, so that it is easily looped over points in the cave. (In practical caving I always use this method rather than the hook, although it is sometimes more difficult to detach. "Friends" or similar variable chocks, maybe normal chocks, may be possible to use; I have never tried it.) A good spotlight is necessary when using the pole; I have a Tekna 4 with 5w halogen bulb.

The distance between the steps (30 cm) is large enough that the stacked steps are easy to separate. Steel cable is too inflexible. The recent model uses 4 mm static kernmantle rope rated at 360 kg, but it has too much stretch and I want to try Kevlar parachute suspension line. I now have no good solution to the problem of sharp edges inside the tubes at the drilled holes. Maybe rivets would work.

At each end of the ladder is a "Fiffi" hook so that the ladder can be used as two Fiffies, which are short cable ladders with 4 to 5 steps, always used in pairs, for extreme climbing. At first I thought it would be necessary to separate the ladder in the middle when used this way, but now I think not; the ladder hangs U-shaped.



The 3 mm cord, generally used to hold the pole together, is now attached with each end to one Fiffi hook. In the middle of the cord it is attached to the harness with a little biner.

The main disadvantage of this system is that you must be very careful because the cords want to entangle the ends of the steps.

With the Fiffi-hook on the end it is also a good retreat device, but for this purpose you can use either the hook or the sling, using the cord for release.

The third way of using it is as a tripod. With a small simple device you make 3 poles of 15 of the steps (5 each pole). The stability is dramatically increased when the tripod is weighted with a sack or other heavy thing.

The ladder makes a package with 14 cm diameter and 25 cm length with a weight of 1870 g complete, without the tripod device. It may be possible to decrease the weight.

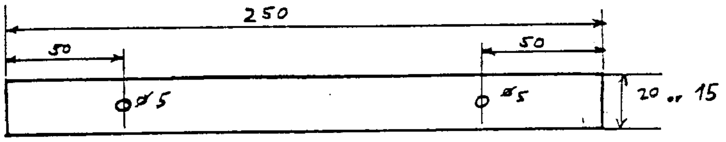
How to make the ladder: After stringing the line through the drilled steps, use a wire hook to pull the cord out of the ends. Make an overhand knot loop at the small steps and a figure-eight loop at the thick ones. The figure-eight loop must be put back inside with the knot pointing inward. The Fiffi hooks are attached very close to the first and last steps. The grappling-iron hook is bent from a 15 cm carpenter's hook and reinforced if possible. The sling is held in position by some short wire pieces, which release when the sling is loaded with weight.

We also used the pole for many other purposes. One time we attached a pulley at the top of the pole and put a rope with weights on its end around a chockstone. The system worked very well. It is also possible to use the pole with a rope attached to its top to reach side passages when hanging on the rope in a shaft.

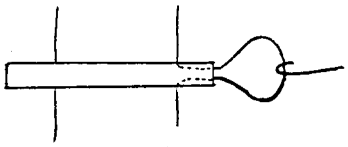
Last, but not least, you can use it for every standard cable ladder purpose and for climbing trees. The hook works very safely in the wood of a tree. You also can use it in combination with other methods (drilling hammer) to make higher ascents.

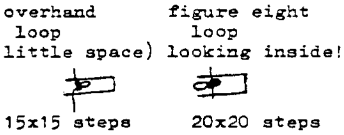
Some cavers say that the hook is too dangerous. Test the attachment before use. I know of no other method to reach a hole in the roof except the bulky scaling pole.

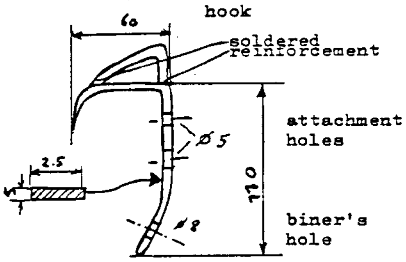
The steps (all measurements in mm)
made from 20x20 mm, 2 mm wall thickness and 15x15 mm with 1.5 mm thickness AlMgSi 0.5 aluminium alloy

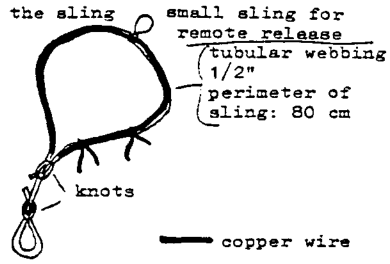


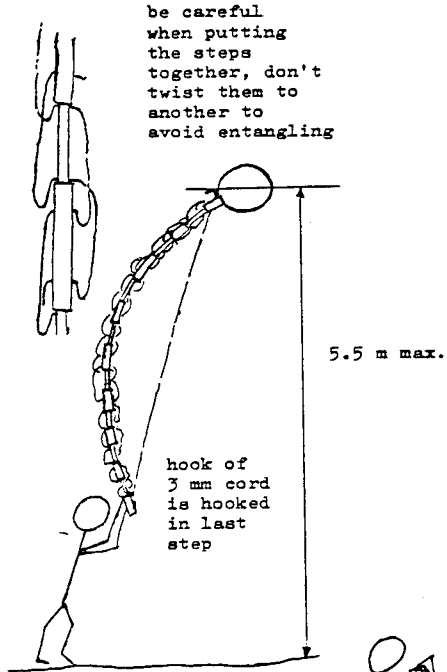
Attachment of the steps

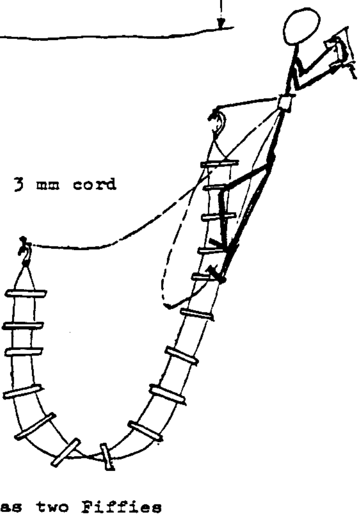


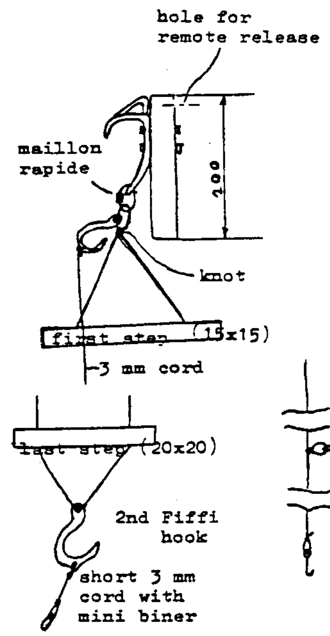


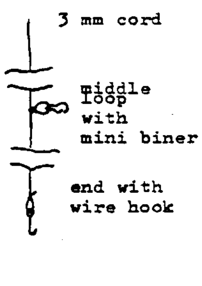


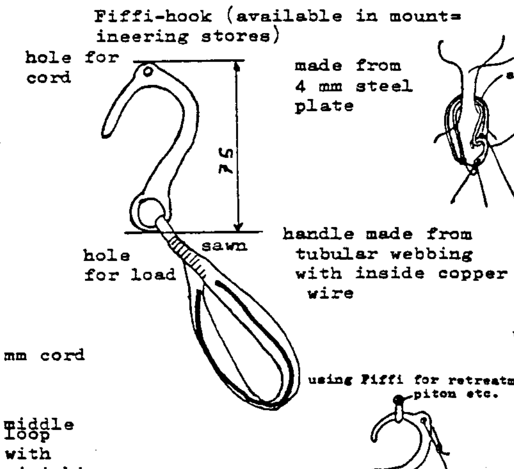


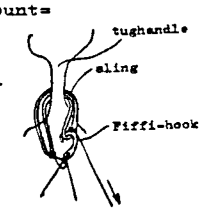


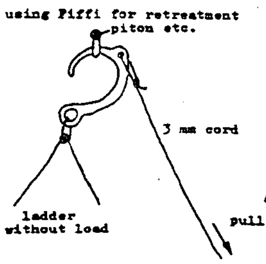


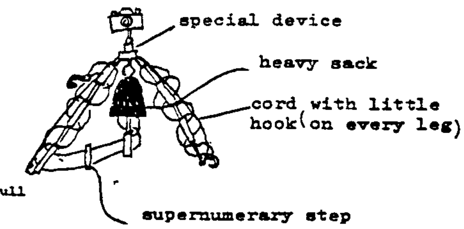












SOME THOUGHTS ON CAVE RADIO ANTENNA DESIGN

One of the important criteria for the design of a cave radio is the antenna design. Here, I will only consider the normal loop antenna, and will not address ferrite core, long wire or other antennas. Variables that can be varied in a loop antenna are the loop size, number of turns, construction method and wire size. The question being asked is "What can we do to optimize the design of the antenna?". For a certain type of transmitting and receiver antennas, I will give the performance and list some conclusions on the optimum antennas.

Ian Drummond, in Magnetic Moments (Speleonics #1-3) has considered the design of antennas, and much of this paper is based on his results. There must be something about the long winters that make Canadian cavers dream of antennas.

We will start off with a few assumptions:

- A receiver and a transmitter loop will be considered, which could be of different sizes or types.
- The loops are tuned with lossless capacitors. Thus the only losses considered are due to the resistance of the wire in the antenna.
- The antennas are perfectly matched to the transmitter or the receiver by a coupling loop or some other means.
- I will ignore the wire skin effects. These could be included, as described by Ian Drummond (Speleonics # 2), but they complicate the analysis.
- I will derive the equations for a circular loop. A square or other shape of loop gives similar results, with slightly different factors.

Let us start off with the transmitter. In the near field, the magnetic field on the axis of a loop antenna can be given (Drummond, Speleonics #1) as:

$$H = n I A_t G / (2 \pi d^3) \qquad (1)$$

The terminology is given below. For a tuned antenna, the power dissapition (W) is entirely in the coil resistance, and can be given as:

$$W = I^2 R \qquad (2)$$

But the coil resistance (R), ignoring skin effects, is:

$$R = 2 \pi r n p / c \qquad (3)$$

which is the resistance of the length of wire in the loop.

Finally, for convenience we will use the wire weight (M_t):

$$M_t = 2 \pi r n c q \qquad (4)$$

By using these equations to eliminate unwanted variables, we get:

$$H^2 = K_t A_t M_t (G / d^3)^2 W \qquad (5)$$

where "K_t" is a factor ($K_t = 1/(16 \pi^3 p q)$ = 12.6 for a circular coil, and 9.7 for a square loop with copper).

Lets now look at the receiving antenna. The voltage induced in a loop antenna normal to the field is given by (Drummond #3):

$$V = 8 . 10^{-7} \pi f A_r n H \qquad (6)$$

The maximum power that can be supplied to a matched receiver is:

$$P = V^2 / 4R \qquad (7)$$

By using equations (6,7,3 and 4) we can get:

$$P = K_r A_r M_r f^2 H^2 \qquad (8)$$

where K_r is a factor ($K_r = 4 \pi\ 10^{-14} / p q = 7.9\ 10^{-10}$ for a circular loop and $6.2\ 10^{-10}$ for a square one with copper)

So combining (5) and (8) we finally get:

$$P = K A_r M_r A_t M_t f^2 (G / d^3)^2 W \qquad (9)$$

where $K = K_r K_t = 1.0\ 10^{-8}$ for circular, and $0.62\ 10^{-8}$ for square loops.

So what does all this mean? The above equation (9) gives the receiver power available in a well matched circuit, based on the transmitter power, coil data and distance between the coils. We can see that the receiver power, and so the performance of the system depends on the following.

- As expected, the transmitted power.
- The receiver power is proportional to the mass of copper used in either antenna.
- It is also proportional to the area of either antenna. Doubling the linear size of either antenna (while keeping the copper mass the same - thus using three guages smaller wire) has the same effect as increasing the transmitter power by a factor of four.
- The "factor of merit" of a loop antenna could be given by the product of the area and mass of the loop ($A_t M_t$ or $A_r M_r$)
- The response between two radios depends equally on both the transmitter and receiver antenna designs. Thus the largest receiver power will be obtained with both antennas large and heavy. However, if the atmospheric noise is predominant, as it is in most situations, a smaller receiving antenna would be as good, preferably with a high "Q" and a high gain receiver.
- The number of turns, as such, makes no difference to the performance of the antenna. A one-turn antenna would have the same performance as a 100-turn antenna, so long as the wire size is adjusted to keep the total copper mass the same, and an appropriate tuning capacitor and coupling method is used for the antenna.
- Coils should be impedence matched to the circuit, which may influence the number of turns used for a coil. However coupling transformers are usually easier to use than adjusting the number of turns of an antenna, to get a good impedence match.
- Surprisingly, the "Q" of the antenna, as such, makes no difference to the performance of the system. However, losses were all assumed in the coil windings, and thus the "Q" will be determined by the wire size and inductance.
- The winding method (e.g. number of layers) and even the inductance of the antenna does not directly affect the performance. Coils do have to be tuned for optimum performance.
- Circular loops are slightly more effective (by 27%) than square loops of the same weight and area.

- The power received would appear to be dependant on the frequency used. However, an increase in frequency will considerably decrease the earth skin depth (see Drummond, #1) and this would tend to offset any advantages of an increase in coil efficiency. The optimum freqency would need to be assessed, based on the relative effect of coil efficiency, skin depth, noise levels, etc.
- The most significant parameter in the field equation is the distance from the coil. Thus to double the range of a cave radio, e.g. to get the same power at the receiver with "d" doubled, assuming we ignore the skin effect, requires increasing the power input by a factor of 64, increasing both antenna masses by a factor of eight, increasing the area of both antennas by a factor of 8, or some combination of these. The skin effect will tend to reduce the range of the radios further. This is not very encouraging to get long range cave radios.

Lets try an example. The first cave radios that Ian and I made had square antennas of 0.7 m sides, and wound with 70 turns of 28 AWG wire. The mass (M) of the wire is 0.14 kg, and the area (A) is 0.51 m^2, and thus the factor of merit (AM) is 0.07. Using the data in Speleonics #3 (f = 115 kHz, skin depth of five so G = 0.068, and distance between the loops of 100 m, with a transmitter power of 10 W) we find using equation (9) that the receiver power will be 1.9 10^{-14} watts, close to Ian's number of 4 10^{-14} watts (difference is probably due to measured versus calculated Q, etc.). We also constructed a larger antenna of four turns of 16 AWG wire on a square loop of 1.5m sides. This has an area of 2.4 m^2, a copper mass of 0.28 kg and a factor of merit of 0.66, over nine times larger than the old antennas. If two such antennas were used, the recieved power should be 163 10^{-14} watts, almost 100 times larger than with old antennas. In fact it was found that the new antenna (only one was made) was superior to the old ones. A futher increase in range should be possible with larger and heavier antennas.

So we can conclude that to get good performance, build the antennas big, heavy and matched to the transmitter, but don't worry about the number of turns or "Q".

Julian Coward.

TERMINOLOGY USED

	Description	Units or Notes
n	Number of turns on the antenna	
i	Current in the antenna coil	Amps
A_t, A_r	Area of the antenna	m^2 (= πr^2 or $4r^2$)
d	Distance between the antennas	m
G	Earth skin effect factor	See Speleonics # 1
W	Power applied to the antenna	Watts
R	Coil resistance of antenna	Ω
r	Radius of antenna (or 1/2 side)	
ρ	Specific resistance of copper	Ω-m (= 18 10^{-9})
M_t, M_r	Mass of copper in the antennas	kg
c	Cross sectional area of wire used	m^2
q	Specific weight of copper	kg/m^3 (= 8800)
P	Power received by receiver	Watts
V	Voltage induced in receiver antenna	Volts
f	Frequency of operation	Hz
H	Magnetic field strength	A/m
K_t, K_r, K	Factors	-

(subscripts $_t$ and $_r$ refer to the transmiter and receiver)

HIGH POWER ON 160-180 KHz?

Frank Reid

The FCC's limitations to unlicensed 160-180 kHz operation (one watt dc transmitter input, 15-meter maximum antenna length) seem prohibitive for cave radio, but **Mike Mideke**, prominent California low-frequency experimenter and LWCA member, has made an interesting point (personal letter, August 1985):

"I'm sure this is a very loose interpretation of the regulations, but my feeling is that if you establish reference field strength levels at several miles, using the best legal antenna system you can manage, then anything goes for antennas and power levels so long as field strength doesn't exceed that obtained with the reference setup—big antennas and very low power, low-efficiency antennas with more power, etc."

RADIOS SAVE CAVES

Frank Reid

Reed's Cave, the third longest in South Dakota (and lying between the 70-mile Jewel Cave and 40-mile Wind Cave systems!) was in danger of being destroyed by quarrying. **John Scheltens**, NSS vice-president and city engineer of Hot Springs, SD, took the owners on a cave trip and showed them the cave's remarkable formations and complexity (3 miles of passage under a 1/4-mile-diameter circle). They agreed to preserve the cave but needed to know its exact location and depth. John asked me to bring the cave radio, and said that the quarry operator would pay travel expenses. How could I refuse?

In August, I had spent a week doing 25 radiolocations in Wind Cave National Park, the deepest of which was 432 feet. The cave survey had indicated a 600-foot depth; the cavers were dismayed at "losing" 200 feet of cave, but a geologist doing master's-thesis research in the area was delighted; he had been unable to explain why the water table in the cave was 200' below the bottoms of water wells in the area!

Dwight Hazen and I spent 27 hours driving each way, through numerous weather-related adventures. We encountered a South Dakota blizzard with precipitation static which caused a continuous arc across the end of the car radio antenna cable, which was hanging loose behind the dash, for several minutes.

We accomplished the mission (four radiolocations), aided by **Dave Springhetti** and other South Dakota cavers, and returned home by a southern route.

In a similar operation, **Ray Cole**, designer of the cave radio featured in SPELEONICS 3, and **Chuck Hempel** made radiolocations at famous Hellhole Cave in West Virginia during the 1985 Old Timers' Reunion. Hellhole is also threatened by a nearby quarry.

CAVE TO SURFACE COMMUNICATIONS

Ron Allum

(condensed)

The communications system was designed and constructed specifically for the 1983 Cocklebiddy Cave expedition, which involved an underground duration of 55 hours. A base camp was established at "Toad Hall", a large chamber 250 metres long, 15-20 metres wide, about 20 metres above the water level. Toad hall was electromagnetically located on the surface, and was the communication post. Communications were required to aid:-

1. Coordination of support divers to assist with the withdrawal of equipment from the cave.
2. To give expedition news and reassurance to the surface party, support divers and media.
3. To enable better utilisation of our reserve air supplies.
4. Co-ordination of rescue and first aid facilities if needed.

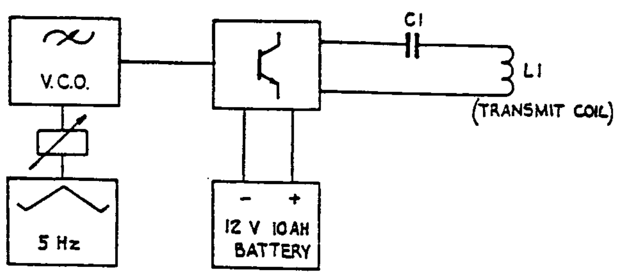
After considering many possible transmission methods, developmental time and facilities available, a system using R.D.F. technology evolved. The following considerations were to our advantage:

1. A weight of several kilos could be tolerated for the R.D.F/comms equipment (feather weight to the 1200 kgs of diving gear taken to "Toad Hall").
2. The terrain above "Toad Hall" is flat, relatively free from scrub, allowing easy search for the transmitted signal. of the R.D.F.
3. Both "Toad Hall" and the terrain above are suitable areas where large aerials can be located.
4. The Nullarbor is relatively free from electromagnetic interference e.g. from high voltage power distribution lines, etc., allowing high-gain receiver circuits to work at low frequency.

An R.D.F. unit (as previously described by Hurst, A.S.F. Conference Canberra 1977) was used but modified to reduce transmitter battery drain.

The transmitter was operated for 25 minutes 'ON', 5 minutes 'OFF'. This cycle could have been maintained for several hours whilst the search for the signal on the surface was taking place. "Toad Hall" lay 2.5 km to the north of the last R.D.F location of the first rockpile chamber.

The modified R.D.F. transmitter:-



L1 is the transmitter aerial, a coil of 260 turns of 1.6 mm dia wire on a 300 mm inside-diameter former. L1 in series with C1 is resonated at approx. 1.8 kHz, by changing the frequency of the oscillator. Current drain from batteries at f_r is aproximately equal to voltage applied divided by series resistance of resonant circuit. About 2 amps can be drawn from the 12v supply. Using a triangular-shaped waveform derived by charge/discharge curves of a timing capacitor when applied to the voltage controlled oscillator, the frequency is varied so that the tuned circuit can be brought to resonance 10 times per second using the applied 5 Hz frequency. Maximum field strength is still obtained at f_r, giving good output field strength, however reducing battery drain by 80%. Unfortunately the R.D.F. described doesn't have an adequate bandpass to allow transmission of voice.

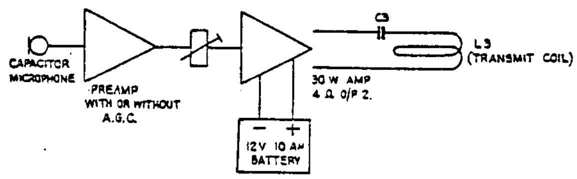
$$f_1 - f_2 = f_r/Q.$$

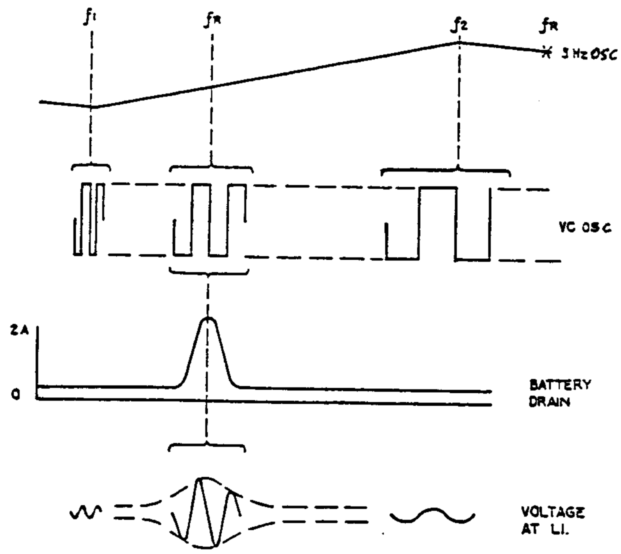
$Q = 1800/60 = 30$ Hz, or 1785 to 1815 Hz.
Q = gain of L_1 at f_r (about 60).

To convey speech intelligently, a bandpass of 1 kHz about a f_r of 1 kHz was tried successfully. A tuned circuit of unity gain is therefore required.

$Q = f_r / (f_1 - f_2) = 1000/1000 = 1.$

The electromagnetic voice transmitter:-

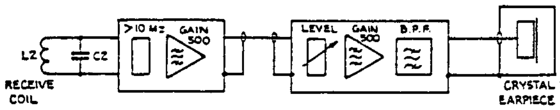




L3 is the transmitter aerial, a coil consisting of 2-by-100 metre lengths of 1 sq mm insulated building wire to form 2 turns, 32 metres diameter. L3, C3 is a tuned circuit, f_r approx 1 kHz, $f_1 - f_2$ approx 1 kHz. Series resistance at $f_r > 4$ ohms.

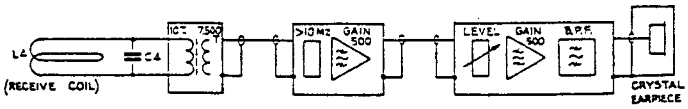
A 30w car stereo booster amp was divided into two amps (one for cave transmitter, other for surface transmitter) and used to drive the tuned circuit. A front-end from a cassette recorder having an inbuilt capacitor mike was use to convert speech to an electrical signal. The circuit used AGC, which was suitable for the cave transmitter but not desirable for the surface transmitter. A preset control allows matching of levels for correct operation of the two amplifier stages.

The R.D.F. receiver:-



L2 is the receiver aerial, a coil of 2200 turns on a 500 mm i.d. former. L2, C2 is resonant at 1.8 kHz. The signal passes through a high-impedance amplifier, than via a level control to another gain stage and a bandpass filter. Note shielding through all stages, including the crystal earpiece. The received signal is that of a "warble" (i.e. 1.8 kHz pulses at a 10 Hz rate).

The electromagnetic voice receiver:-



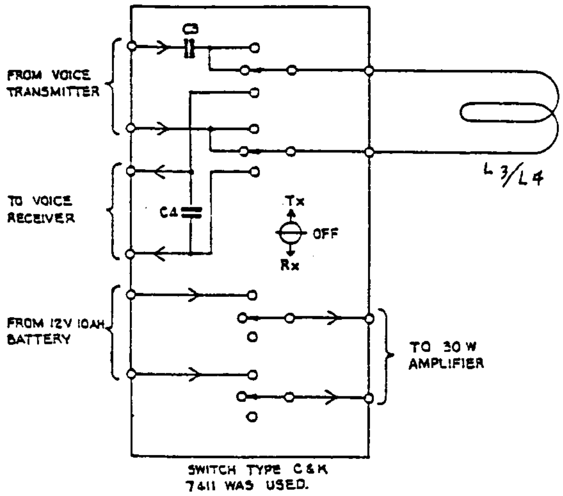
L4, C4 are similar components to L3, C3 of the voice transmitter, except parallel-tuned. Impedance matching is achieved by a 4 ohm : 2.5 Megohm transformer.

Although the amplifier stages appear very similar to the R.D.F. receiver described earlier, their high/lo rolloff frequencies were tailored to the bandwidth of the voice transmitter (700 Hz to 1.7 kHz).

Note: Aerial is connected to transmitter in the switch centre position before 12V supply is turned on to transmit.

The above switching shows how the units are combined to share the common aerial. Cave and surface transceivers are similar. The aerials are located one above the other (R.D.F. used to locate the aerials' axis).

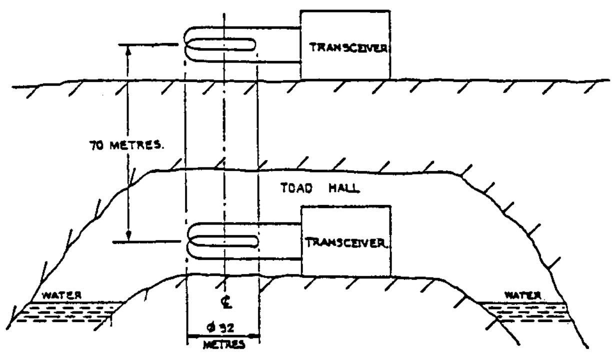
The electro magnetic transceiver:-



The previously-mentioned switch-on schedule was used: The R.D.F. transmitter was tuned 'ON' for 25 minutes, then 'OFF' for 5 minutes. The 'OFF' time was used to establish communications; if not made, the cycle was repeated.

The communications system worked very well, even with limited development time and no field measurements. It is felt that many improvements can be made. The transmit/receive coils' inductance was never measured but is thought to be about 0.6 mH. The first receiver amplifier stage had too much gain; the gain control between the two stages had to be near minimum to receive an undistorted signal.

The concept of the unit was designed about the close mutual coupling between the two aerials, being derived by large coil diameter (approx. 32 metres) and the relative spacing between (approx 70 metres). Had development time permitted, small dia. coils would have been tried, making the unit suitable for other cave requirements.



HOW TO MAKE AN ULTRASONIC RANGEFINDER

Bill Mixon

[Originally published in Compass & Tape, the newsletter of the NSS Survey and Cartography Section, vol. 2, #2, fall, 1984.]

Bill Torode's review of the Kwik Tape in the summer Compass & Tape reminds me of a similar experiment by Frank Reid about five years ago. He had bought an experimenter's kit from the Polaroid people that included the circuits they use for the ultrasonic rangefinder in some of their cameras. I was with him in James Cave, Kentucky, when he tried to use it to measure ceiling heights. Besides the problems of ledges and irregular walls and ceilings that plagued Torode's experiment, we were amused to discover also that flying bats totally jammed the unit, causing it to read out apparently random numbers. Not surprising, when you think about it.

I would guess that the Kwik Tape in fact incorporates the Polaroid device. It certainly must have something like it. And the difficulty of using a device that depends on echoes in an irregular passage is obvious. Torode correctly observed that what one needs is something with separate transmitter and receiver. I have had a mental design for such a thing since about 1970, and I have described it to a number of people who might have been capable of building it. But so far nobody has. Perhaps this note will stir up some action.

The problem with echoes is that they come from everything within the beam, which can't be very narrow because sound waves are roughly an inch long and a transducer for use in a cave can't be very many inches wide. The polaroid device detects the first echo, on the reasonable assumption that the user will want to focus on the closest object near the center of the picture. But the first echo is almost certainly not useful in cave surveying, since it will usually come from an irregularity on the walls, floor, or ceiling that is closer to the instrument than# the intended target. There may well, in fact, be no source at all of a prominent echo at the intended target, since the next station may be the tip of a tiny# formation or just an arbitrary point on a slowly curving wall. The solution is to have the transmitter at the next station and to measure the time between the transmission of the sound and its arrival at the instrument. In this case, the earliest detected sound is what is wanted, since echoes from walls and other things will follow less direct paths and take longer to reach the receiver than the direct beam.

My idea is very simple. A device held at the target station would, when a button was pressed, simultaneously emit a flash of light and a burst of sound. The light might come from a cheap, low-power photographic strobe. The instrument at the previous station would measure the elapsed time between the arrival of the light, which we can assume travels infinitely fast, and the sound, which travels quite slowly.

Sound travels roughly 1100 feet per second, or about an inch in a tenth of a millisecond. In order to be able to time the arrival of the sound pulse within a tenth of a millisecond, we want the wavelength of the sound to be a fraction of that, or, equivalently, the frequency to be several times 10 kilohertz. Perhaps 40 kilohertz, which is ultrasonic, would do nicely. High-frequency sound is severely attenuated in air, especially moist air, so you don't want to use a higher frequency than necessary. (At room temperature, air with 100 percent humidity absorbs 40-kHz sound at 27 db per 100 feet.)

It would be necessary to calibrate the ultrasonic tape for the particular cave conditions, since the speed of sound depends on both the temperature (changing about 1 percent per degree) and the elevation (about 1 percent per thousand feet). This could be done by taking one reading over a taped distance in the cave. But it sure would be nice not to have to use a tape on every shot.

Such a gadget should be able to substitute for the traditional tape. Since it requires a transmitter at the target, it is no good for measuring the height of inaccessible ceilings and such, of course, so it does not really do all that the Kwik Tape sort of thing might have done, had it worked. And it is certainly not inherently immune to jamming by bats, though a clever engineer might be able to avoid the jamming without adding too much complexity. I'd be interested in hearing from anyone who builds such a thing.

CAVING WITH THE POLAROID ULTRASONIC RANGEFINDER

Frank Reid

When I first received my Polaroid rangefinder experimenter's kit, I rushed to the entrance room of Buckner Cave to try it out. The beam is surprisingly narrow (-3 db width about 8 degrees); I immediately learned that it requires an attached spotlight for aiming. The ultrasonic ranging pulses seemed to severely disturb a small cluster of bats on the ceiling.

The Polaroid device is a sophisticated design; it emits a successive burst of multiple ultrasonic frequencies (similar to the swept-frequency chirps of bats) in order to eliminate false readings caused by resonances. The receiver gain is increased in a series of timed steps after each pulse is transmitted, to reduce false readings caused by echoes from nearby objects not in the main beam. The unit is supplied with excellent documentation.

I cave-proofed my rangefinder by installing it inside an old Civil Defense geiger counter case which cost $1 at a hamfest. The outer shell of a military-type connector with screw-on cap protects the transducer when not in use. I mounted a flashlight reflector assembly (found in Buckner cave) in the meter-hole of the case, and connected the bulb to a separate switch and pair of D-cells (The rangefinder uses a 6-volt flat Polaroid "letter bomb" battery).

We used it very successfully for measuring distances to walls and ceilings in large passages We didn't use it for measuring distances between survey stations because most of these were greater than the unit's maximum range. The unit's digital readout will not indicate distances greater than 30.4 feet.

At about the same time, **Richard Breisch** also evaluated a Polaroid rangefinder for caving purposes, taking a different approach-- He mounted the transducer on a tripod and collected range data for each 10^{o} of horizontal or vertical rotation. A computer could then plot an outline of the passage. His paper was presented at the Computer Applications session of the NSS Convention and International Congress of Speleology in Bowling Green, Kentucky, 1981.

INEXPENSIVE 2.5 MHZ WWV RECEIVER

Frank Reid, W9MKV

Ordinary AM transistor radios can be converted to receive WWV, the National Bureau of Standards time-signal station at Ft. Collins, Colorado. Tune the radio to 1590 kHz and remove turns from the antenna coil until it resonates at 2.5 MHz. Used radios are available at garage sales and hamfests for $1 or even less.

A WWV receiver is, of course, useful for setting clocks. It is necessary for such esoteric caving applications as determining true north by star sighting with a transit or theodolite. (Changes in magnetic variation can seriously affect the accuracy of cave maps surveyed over several years.) This project is also a good exercise in understanding the inner workings of superheterodyne receivers; it works by enhancing the image response, a normally-undesirable aspect of superhets.

The conversion can be done without instruments, but a digitally-tuned communications receiver is a great help. The communications receiver should tune 400-500 kHz and 2-3 MHz.

1. USE THE COMMUNICATIONS RECEIVER TO CHECK WWV SIGNAL STRENGTH. The range of WWV's 2.5-MHz transmitter is less than that of its others on 5, 10, 15 and 20 MHz. If you are in a weak signal area (e.g., east of the Mississippi), do the conversion procedure at night when signals are strongest.

2. FIND THE INTERMEDIATE FREQUENCY OF THE RADIO TO BE CONVERTED. Most transistor radios have a 455-kHz i.f's but the frequency may vary; the last radio I converted (5-transistor, Midland brand, made in Taiwan) had a 473-kHz i.f.

Tune the radio to any local AM broadcast station. Loosely couple the radio to the communications receiver (e.g., connect a single wire between the communications receiver's antenna terminal and one battery terminal of the transistor radio). Tune the communications receiver around the 455-kHz region to find the transistor radio's mixer output (same station heard in both radios' speakers). The frequency displayed on the communications receiver's readout is then the Intermediate Frequency of the radio under test.

3. SUBTRACT THE INTERMEDIATE FREQUENCY FROM 2500 KHZ. Example: 2500 - 455 = 2045 kHz. The receiver's local oscillator must be at 2045 to receive WWV. Using the same test setup as above, set the communications receiver to 2045 kHz and tune the transistor radio until the comm. receiver detects the local oscillator. The dial setting of the transistor radio will be 2500 - (2 x 455) = 1590 kHz.

4. REMOVE TURNS FROM THE ANTENNA COIL UNTIL IT RESONATES AT 2500 KHZ. Connect an external antenna (long wire, 100+ feet) to almost any point inside the radio, e.g., a battery terminal. Continue monitoring the local oscillator frequency as above, readjusting as necessary for drift or after disturbance of the tuning knob.

More than half the turns of the antenna must be removed. Start unwinding from the end furthest away from the coil tap. After finding the right number of turns, discard the extra wire, secure the loose end with melted wax, and solder it to the proper terminal. Adjust the antenna trimmer capacitor (one of two trimmers on the back of the main tuning capacitor) for maximum WWV signal. One trimmer adjusts the local oscillator frequency, the other tunes the antenna.

The converted receiver will tune frequencies other than WWV, including strong AM-broadcast stations, but is primarily useful as a single-frequency receiver because the local oscillator and antenna tuning no longer track each other properly. There may be interference from strong local broadcast stations at the frequency to which the radio was initially tuned during conversion.

External antennas will be needed in some areas. A long wire (or earth ground) attached as described above is usually sufficient; you may wish to experiment with external antennas and grounds connected to a few turns of wire around the ferrite antenna rod.

This conversion technique can be used between 1450 and 2510 kHz, which includes the 160-meter ham band where successful cave-to-surface voice communication experiments have been made. Common transistor radios are rather insensitive; an external frequency converter would offer better performance. See recent issues of QST magazine describing projects based upon converted AM broadcast receivers.

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JOHNSTON, LEWIS PAUL 15980 KA5FYI #4 207 W CRESTLAND AUSTIN TX 78752
JORDEN, JAY R. 14336RF #4 1510 DEVON CIRCLE DALLAS TX 75217
KATZ, MICHAEL A. 23885 #4 655 THIRD AVE STE 1100 NEW YORK NY 10017
KAYE, TOM 16356 #4 3245 RIO DR #804 FALLS CHURCH VA 22041
KNIGHT, SHEILA 14291 #4 1510 DEVON CIRCLE DALLAS TX 75217
KOWALSKI, GARY 23895 #4 413 S. LINCOLN ENID OK 73703
LAIDLAW, KENNETH N. 5664LF W6GFE #4 870 WILDCAT CANYON RD BERKELEY CA 94708
LARSEN, CHUCK #6 RT 2 BOX 713 GARLAND TX 75040
LINDSLEY, PETE 5566RF #5 RT 9 BOX 221 MCKINNEY TX 75069
LUCAS, PHILIP C. 4073RF #4 2 LAKEWOOD CIRCLE ALTAVISTA CA 24517
MACGREGOR, KIRK 5901FFP #4 78 KING HIGH AVE DOWNVIEW, ONTARIO CANADA M3H 3B1
MAEGERLEIN, STEVE 5340RFP #4 BOX 60 WILLIAMS IN 47470
MARTINEZ, SAM 23935 #1 1033 EAST 18TH STREET TULSA OK 74120
MAVRELION, JAMES 19668 #4 PO BOX 5 NEWTON JUNCTION NH 03859
MCCARTER, MICHAEL, DPT MINE ENG #8 313 W20, UNIV. OF UTAH SALT LAKE CITY UT 84112-1183
MELE, GARY 20779 #4 2103 A MENALTO AVE MENLO PARK CA 94025
MILLER, RONALD E. 14900 #4 3613 CLAY HIGGINS RD FT WORTH TX 76109
MIXON, WILLIAM 5720 #4 7413 GROVER AVENUE AUSTIN TX 78757
NABICH, ROBERT F. 11345 #4 22045 ROYALTON RD STRONGSVILLE OH 44136
NAVARRE, MARK 24032 #4 10514 LUDLOW HUNTINGTON WOODS MI 48070
OLSEN, BERT WA5PSY #6 222 MIZELL DUNCANVILLE TX 75116
PEASE, BRIAN L. 7476 W1IR #4 567 FIRE ST OAKDALE CT 06370
PORTER, CHARLES O. 5330 #6 1934 FIFTH AVE. TROY NY 12180
QUINLAN, JAMES F. 3021RF #5 BOX 8 UPLANDS RESEARCH LAB MAMMOTH CAVE KY 42259
RAINES, TERRY 6154LF #4 BOX 7037 AUSTIN TX 78712
REAMES, STEVE 25533 #6 1949 PALM DR COLORADO SPRINGS CO 80907
REID, FRANK S. 9086 W9MKV #4 P O BOX 5283 BLOOMINGTON IN 47402
ROCHE, BERNIE 18402 #20 8 GODSTONE ROAD, #802 WILLOWDALE, ONTARIO CANADA M2J 3C4
SANFORD, RICHARD J. 6043 #4 PO BOX 4175 COLESVILLE MD 20904
SCHAVEY, RUSSELL & SUSANA 6297 #4 6801 TROPICAL SHORE WAY TAMPA FLORIDA 33615
SCONCE, W. J. "BILL" 6819 N1BFX #4 PO BOX 85 MILFORD NH 03055
SIDES, STANLEY & LINDA 5217RF K0QMV #4 2014 BETH DR CAPE GIRARDEAU MO 63701
STRAIT, DOUG 9707 #4 44 OAK ISLAND DR YAUPON BEACH NC 28461
SUTHERLAND, WAYNE H. 12246 KC7QE #4 RT 1 CPR #29 BUFFALO WY 82834
TAYLOR, GARY 24217 #4 213 ESCALON STREET CINCINNATI OH 45216-1706
TAYLOR, DAVID S. 6858 #4 PO BOX 242 CLARKSVILLE ARKANSAS 72830
TAYLOR, FONCEY 25120 WF7Y #4 539 D 14TH ST OGDEN UT 84404-5813
TOUSEK, JARVIS 20451 #4 4315 EDGEHILL WICHITA FALLS TX 76305
VAN SWEARINGEN, JOHN 12038 #4 RD 2 BOX 591 SOMERVILLE AL 35670
VERNIER, RICHARD 16960RP N9AKV #6 LAKE RD. RR 2 PRINCETON IN 47670
WALKER, ROBERT S. 8259 #4 9110 US HWY 42 PROSPECT KY 40059
WALLACE, JOHN-ELEC ENG DEPT 6786 K4TU #4 GEORGIA INST. OF TECHNOLOGY ATLANTA GA 30332
WEST, ROBERT L. (RB) 13833 KV4C #4 2741 BALDWIN BROOK DRIVE MONTGOMERY AL 36116
WHITEHURST, BRYAN 19070 [illegible] #4 316 E. 18TH ST TULSA OK 74120
WHITEHURST, TOM H. 12919 [illegible] #4 3912 CASE HOUSTON TX 77005 77005
WIGGINTON, LARRY JOE 9734 #10 900 E ROCK COVE ROUND ROCK TX 78664
WIGHTMAN, REV PAUL-ST MARYS CHURCH 825RF #4 ITASCA STAR ROUTE PARK RAPIDS MN 55470
WILKINSON, QUINTA 20525 #4 4516 BARNETT RD #1022 WICHITA FALLS TX 76310
YECKEL, JACK 10060 KA8MCH #6 1590 BRUCE AVE CINCINNATI OH 45223

LATE SECTION NEWS

Joe Giddens

GRANT RECEIVED

The Alberta government's Workers' Health, Safety and Compensation Department has supported work on emergency communication and rescue in caves and mines. Recognizing the contribution of cavers to this field, they have awarded the Alberta Speleological Society a grant. In turn, the ASS has awarded the Communication and Electronics Section 300 Canadian Dollars toward supporting publication of SPELEONICS, and another 300 Canadian dollars toward purchase of material dealing with underground communication and electronics for the NSS Library. The section gratefully acknowledges these grants.

SECTION BROCHURE AVAILABLE

Section secretary Frank Reid has completed a section information brochure, now available from the NSS, section officers, or from the treasurer for an SASE: PO Box 170274, Arlington, TX 76003.

TIME TO RENEW!

This issue marks the end of our Section's very successful first year. We now have more than 100 members. People from all over tell us how refreshing it is to find a publication that takes caving electronics seriously!

For many of our esteemed charter members, issue #4 is also the end of a subscription. We think SPELEONICS is an outstanding value among caving publications. If you agree, please renew! Subscription rates are unchanged. You may, of course, extend your subscription at any time.

James Jasek sends the following article from the New Zealand Speleological Bulletin 7:(130), June 1984, about a unique single-wire telephone system. Jim says, "This is the only article I have seen where the schematic was actually shown. All the others working on these phones seem to keep this part a secret. This one actually works."

(Condensed Reprint:)

THE MICHIE PHONE SYSTEM

Barry Were, Hamilton

Most cavers realize the value of communications in cave rescue. Conventional telephones have several problems. Two wires mean twice the weight of wire to run. If one wire is cut, the other wire will conceal this fact by holding the ends together. Connections to two wires are more tedious to make, and the phones themselves are often bulky and heavy.

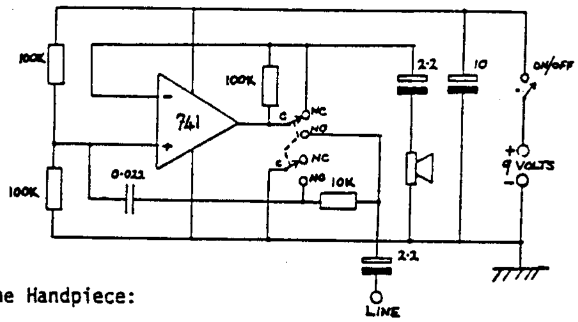
The old principle of using the ground to provide a return signal path is easily realized by using modern electronic devices, thus a lighter, more portable and hopefully more reliable system of communications can be provided.

The system was designed by N.A. Michie of Australia around 1974. Full technical details were published in the Journal of the Sydney Speleological Society 1974 18(11). The N.Z. version is very similar.

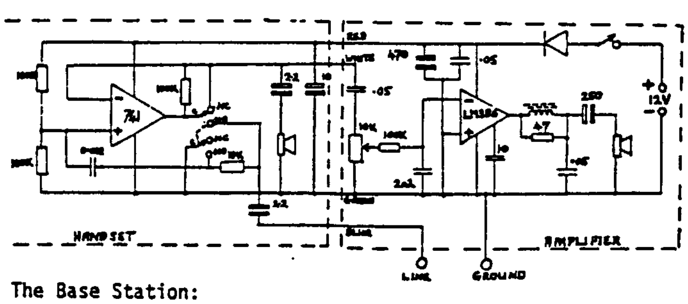
THE HANDPIECE. This is built around a telephone earpiece rocking-armature microphone/speaker which features good moisture seals and low cost. (Ed. note: These are sound-powered telephone transducers. High-impedance magnetic earphones should also work.) A 741 operational amplifier is arranged on receive to operate as a voltage-follower. It is well able to drive the speaker while presenting to the line a nominal impedance of 60K ohms. This impedance is the secret of the incredible range of the system. In the transmit mode, the DPDT push-to-talk switch reconfigures the system to provide gain. It will thus supply typically 3 volts RMS into the line with a maximum current of 10 mA. The receive and switching configurations are designed for good stability even in the presence of mud and water. The 9v battery typically supplies 0.6 mA on receive and up to 10 mA on transmit depending on the impedance of the wire. Battery life on receive is at least two weeks, down to 8v. The system is still operational at this voltage.

Each handpiece is made of aluminium box section material which provides a good electrical connection to the hand of the user. The signal finds its way to ground through the user's body.

The handset contains a 9v battery with a life expectancy of 2 weeks, should the on/off switch on top be accidentally left on. Also on top is push-to-talk switch which puts the handpiece into transmit mode. A wire leaving the box has a clip on it to connect to the wire running through the cave. Connection may be made at any point and usually this clip will cut the insulation if squeezed hard enough. The clip must make contact through the insulation for the system to operate. The telephone-style earpiece is sealed and is thus waterproof. The handpiece, however, has been designed so that water can get out easily, since it never seems to have any trouble getting in. While it will work even when completely full of water, the performance is deteriorated. Mud must be kept out of the unit.



The Handpiece:



The Base Station:

BASE STATION. The microphone circuit is identical to that of the handpieces (without the on/off switch) and is thus able to listen as well as transmit. The bigger speaker and its amplifier make it easier to monitor traffic. A volume control is provided. A connection has been made to the metal holder on the rear of the microphone to enable a temporary earth through an operator if the system is to be used before a more permanent earth is established. This will work on both receive and transmit but is only effective while being held. The Base Station's one-watt single-chip integrated-circuit power amplifier (type LM386) has a low quiescent current requirement which results in a total standby current drain for the base station of 7.5 ma with a 12v supply. The amplifier incorporates a lot of radio frequency protection which should enable it to be used in the proximity of a transmitter without interference.

The two 6v lantern batteries should give several weeks' operation. Clips provide a connection to an alternative 12v battery, and reverse-polarity protection is included.

The Base Station is not waterproof and the speaker will be wrecked by water. For carrying, the station fits into an ammunition box with the batteries and 3 handpieces.

A total of 13 handpieces and 2 base stations have been constructed. These cost about $14 per handpiece and $25 per base station, including batteries.

THE WIRE. Either solid-conductor or stranded insulated wire can be used. The system has been tested using 7/0076" wire in Matthews Cave. At least 1 km of wire was run-out, and provided excellent voice contact.

Joins in the wire are not critical so long as a good knot is tied to take the strain before the bared ends are twisted together.

SETTING UP AND OPERATING. Setup and operation are easy. The Base Station requires an earth connection. A stake or two may be driven into the ground, preferably where it is moist. An even better earth can be had by running a wire to a nearby stream and attaching it to a submerged metal object (aluminium Xmas pud dishes have been found ideal for this).

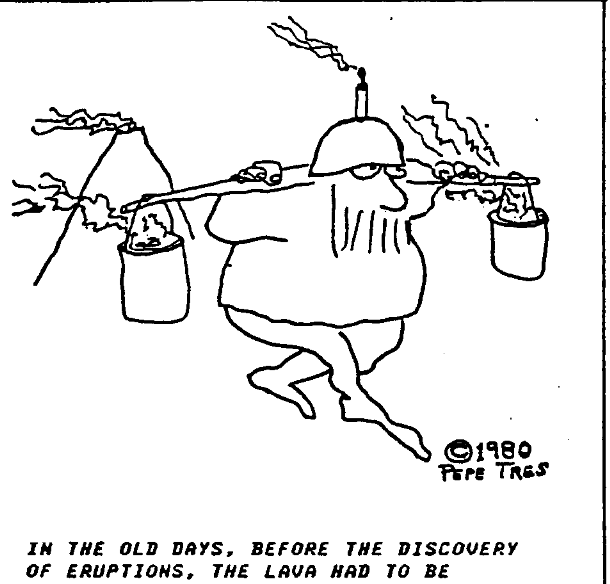
Running the wire is a simple job for two people. Care should be taken to ensure the wire is kept clear of main traffic areas through the cave. Usually, it can be hooked over projections or weighted with rocks without the need for knotting the wire round things every few metres. A little thought in running the wire can save lots of time when it is being reeled in again at some later stage, when the enthusiasm for the project is generally wearing off.

The line can be branched simply by stripping the insulation off the main wire sufficiently to twist in the end of the branch wire. Once the wire is in place, it is a simple matter for people to clip their handpieces to it and speak. There is no limit to the number of handpieces which may be attached at any time, although things can get pretty hectic with 10 people all attempting to chat to each other at the same time.

AFTER USE. Thoroughly dry out the Base-Station and the handpieces before they are stored away. Moisture will cause corrosion of the copper components and the switches. Unnecessary dunkings of the handpieces in water should be avoided. Mud in the battery connectors can cause battery discharge even with the handpiece switched off.

Batteries should all be replaced after prolonged system usage. Regardless of use, all batteries should be replaced every two years anyway.

Editor's note: Please let us know the results of experiments with this system or variations thereof. It would be especially interesting to know if these telephones detect signals from audio-frequency "cave radios" operating in electromagnetic or earth-current mode.



IN THE OLD DAYS, BEFORE THE DISCOVERY OF ERUPTIONS, THE LAVA HAD TO BE CARRIED BY HAND DOWN THE MOUNTAIN AND THROWN ON THE SLEEPING VILLAGERS---THIS TOOK A LOT OF GEOLOGICAL TIME!

INPUT WANTED

The success of any special-interest group depends upon the enthusiasm of its members. We urge **you** to write articles for publication in SPELEONICS; they needn't be formal or prepared in any special way. A letter to the editor is a quick, easy way to distribute an idea. We also need papers for presentation at our NSS Convention session. There will be informal presentations there also, so bring along your favorite caving-electronic project to show!