speleonics 15 OCT. 1990

volume IV number 3

Fig.1.

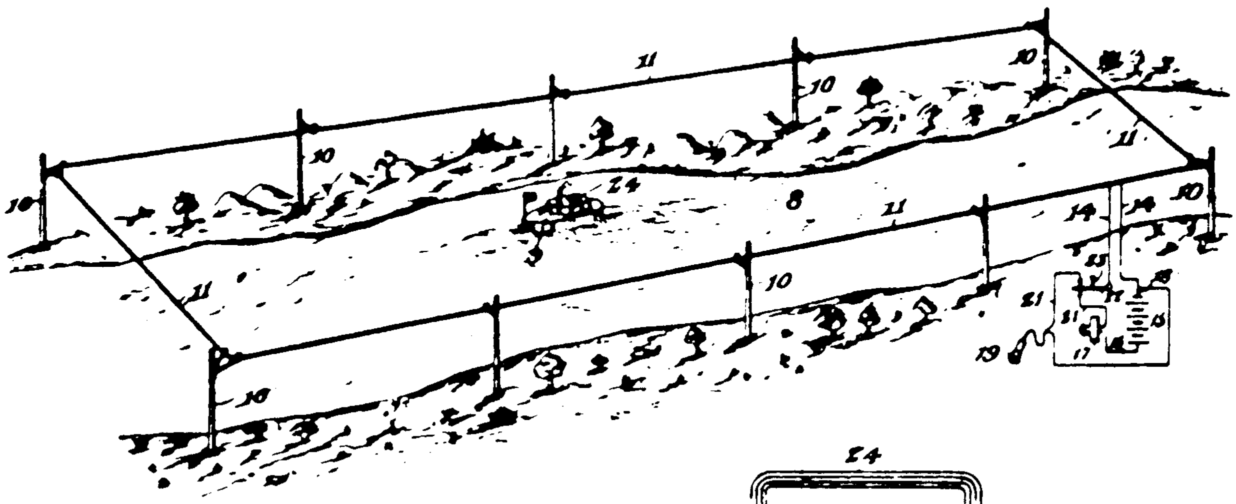
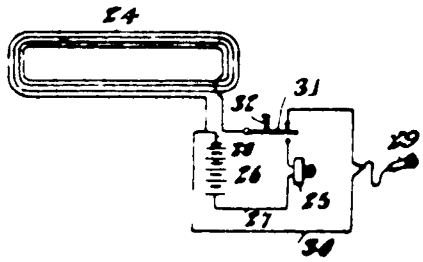


Fig.2.



SPECIAL HISTORY ISSUE

These drawings are from U.S. patent number 887357 for a wireless telephone, issued in 1908 to Nathan B. Stubblefield of Murray, Kentucky. Stubblefield pioneered principles now used in "cave radio."

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SPELEONICS 15

Volume IV, Number 3 October 1990

SPELEONICS is published approximately four times per year by the Communication and Electronics Section of the National Speleological Society (NSS). Primary interests include cave radio, underground communication and instrumentation, cave-rescue communications, cave lighting, and cave-related applications of amateur radio. NSS membership is encouraged but not required.

Section membership, which includes four issues of SPELEONICS, is $4.00 in USA/Canada/Mexico, $6 overseas. Send subscriptions to section treasurer Joe Giddens at the address below (make checks payable to SPELEONICS.) If you have a ham-radio callsign or NSS membership number, please include them when subscribing.

Foreign subscriptions can be paid in U.S. "paper" dollars in the mail; an international money-order may cost as much as the subscription itself. Many members have sent cash without problems. (No foreign currency, please.)

Editorship rotates among the officers. Volunteers are encouraged to guest-edit or produce an issue. A technical session, followed by election of officers, is an annual event held during the NSS Convention.

Complimentary copies of SPELEONICS go 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

SPECIAL HISTORY ISSUE. The inductive and earth-dipole principles used today in wireless underground communication were known long before anyone thought of using them in caves. In this thirtieth year after **Eugene R. Roeshclein**'s influential cave-radio article, we reprint it and other history in hope of stimulating experimentation. We emphatically do NOT intend to resurrect ancient acrimonious debates over who was first. --F.R.

NEWS AND ANNOUNCEMENTS

$2500 REWARD FOR 2-WAY VOICE CAVE RADIO!

Steve Hudson, maker of PMI rope, participates in difficult and all-too-frequent rescues in Ellison's Cave. He sorely needs reliable cave radios with two-way voice. The British Molefone (see SPELEONICS 8, p.4) fulfills the requirements, but delivery lead-time is very long, and construction does not allow easy repair. Steve's rescue squad has appropriated $2500 (the approximate cost of a pair of Molefones), but would prefer to "buy American" if possible. For further details, contact:

Steve Hudson / Rt 4, Box 1365A / Lafayette, Georgia 30728
phone: (404) 764-2296
--

SPELEONICS 17: INSTRUMENTATION

Ian Drummond, editor of issue #17, says that it will specialize on underground instrumentation, e.g., meteorological, hydrological or biological measurement equipment. If you are working on instrumentation projects, please contact Ian.
--

FCC NOW CLAIMS 9 kHz

The Federal Communications Commission formerly claimed no jurisdiction over frequencies below 10 kHz. The limit has been decreased to 9 kHz: The current (October '89) FCC regulations book (47 CFR parts 0 to 19) has a spectrum allocation chart. The first row is "Below 9 Khz." [Adapted from posting by markz@ssc.uucp on rec.ham-radio, 6 May 1990.]

THIRD ANNUAL MEETING AT DAYTON HAMVENTION

Ten people attended our third informal meeting at the world's largest hamfest. The outdoor location (see SPELEONICS 14) was satisfactory-- quiet, easy to find, and near a door in case of rain. We will try the same place next year.

Members and friends present:

Betty Bunting	Reno Lippold
Bill Bunting [new member!]	Frank Reid
Don Conover	Gary Taylor
Mike Gray	Phil Temples
Dean Harris	Jaque Yeckel

We compared notes on whereabouts of unusual and "cavish" things including a military-surplus precision surveying altimeter (conditon unknown; $260), 700 feet of 7/16" hard Goldline rope in four pieces ($70), King 8001 LORAN-C receiver ($300), a precision mercury barometer ($100), and Brunton compasses with mil scales (poor condition; $10). I bought a geophone for $1 and a pair of army field-telephones for $5 each (excellent condition but no handsets). Used lead-acid "gel-cells" from 2.5 to 25 amp-hours were plentiful and inexpensive. Maybe someday we will get lucky and find a pile of used electric miners' lamps for $1 each. *(:-)

NSS conventions are infamous for bad weather. Flashfloods and lightning have hit campgrounds. Someone suggested that a portable weather-radar would be useful. We saw an X-band aircraft radar at Dayton for $600.

My pedometer recorded 18.2 miles (29.1 km) in two full days at the hamfest, plus a trip to the Air Force Museum.

LETTERS

The KMZ10A magnetoresistive sensor [SPELEONICS 14 p.14] is $3.50 (100's) from Philips' rep at the Huntsville, Alabama office... I don't know the price per piece, but telephone number is 205-837-7105. Ask for Ray Maynor and he can fax you some data sheets...

Chuck Thurman WB5KFN
Rt. 4 Box 908
Hattiesburg, Mississippi 39402
--

The article on Exploding Cameras (SPELEONICS 14) reminded me of a similar event that I witnessed about ten years ago. I was on a photogarphy trip in Wolf River Cave (Fentress County, Tennessee) with a bunch of cavers from Ohio. We had just reached the Enchanted Forest, and were starting to photograph the formations, when a loud KABOOM! echoed down the canyon. When we looked to see what had happened, we saw a caver with a stunned expression, holding the remains of his electronic strobe.

Fortunately, he wasn't hurt. After picking up the pieces of his strobe, we reconstructed the accident as follows:

1. He had carried his camera gear into the cave in a backpack, tightly wrapped in a plastic garbage bag to protect the camera from moisture.

2. He had put his dump bag, with spent carbide in it, in the same garbage bag.

3. Presumption: Acetylene from the not-quite-spent carbide permeated the strobe.

4. Result: When he tried to take that first picture, a spark inside the strobe ignited the acetylene-air mixture, blowing the strobe to pieces.

John Barnes
216 Hillsboro Ave.
Lexington, Kentucky 40511
--

To supplement your article on Monitoring Magnetic Declination (SPELEONICS 11, p.9), tabulations of the historical change in declination are available from the National Geophysical Data Center, a division of NOAA.

These tables show the values at intervals of 5-10 years and extend back to 1750-1850. These estimates of declination can be made for any location within the original 48 states of the USA; approximations might be possible for nearby locations in Canada and Mexico by extrapolating from the tables.

To get a table of historical declination, determine the latitude and longitude (in degrees and minutes) of your location of interest, and call or write:

W. Minor Davis
National Geophysical Data Center
Code E/GC1
325 Broadway
Boulder, Colorado 80303
telephone 303-497-6478

For one or a few locations, he might be able to send you the tables at no cost. There is a basic fee of about $10 per location, but this might be applied only when there is a request for a large number of locations.

I have a copy of the computer program which the NGDC developed and uses. I will also be happy to send a table of historical declination to anyone who sends me their desired coordinates; a post card would be fine.

Bruce Bevan
P.O. Box 135
Pitman, NJ 08071

Resources and New Products

SHF Microwave Parts Company
7102 W. 500 S.
LaPorte, Indiana 46350

This is a source of Solfan, MA-Com and other brands of X-band Gunn-diode oscillators and detectors, useful for communications, motion sensing, doppler radar, and testing radar detectors. ;-) The devices are tuneable into the 10 GHz ham band. Prices start at $15. A book of plans is also available. Send SASE for brochure.
--

C and H Sales Company
2176 East Colorado Blvd.
P.O. Box 5356
Pasadena, CA 91117-9988 USA
phone 1-800-325-9465

They have an 118-page catalog of mechanical, electrical, and optical surplus. Of special interest might be the Wallace and Tiernan surveying altimeter for $150. They also have an army-surplus gyro compass and theodolite, vintage 1968. [contributed by **Bruce Bevan**]
--

SEE NEXT PAGE ------------>

ATOMIC STROBES AND OTHER EXPLODING THINGS

Paul Johnston, KA5FYI *

I read with interest the article about the exploding LeClic All-Weather Camera and the Prinz Jupiter flashgun.[1] I, too, know the feeling of being like a cartoon character holding a stick of dynamite, and B-A-N-G! After the smoke clears, only a charred, crispy critter remains.

One of my friends, Dave Albert, had a strobe blow up on him. The complete details are given in American Caves and Caving.[2] In short, the culprit was the transporting of an electronic strobe in the same pack with his spare carbide. The pack was wet, and the lid had come off the carbide container. Acetylene built up inside the strobe, and when he took the picture, well, it was the ole stick of dynamite effect... The same book mentions other instances of acetylene explosions underground.

On a personal note, I owned a Subsea Mark 150 underwater strobe. I used this in my underwater photography work in the early 1970's. It was powered by a 510-volt Eveready No. 479 non-rechargeable battery. On a three-week trip to Cozumel, Mexico and Belize, I used this strobe continuously without taking the battery out of the housing. Keeping underwater photography equipment from leaking is a real problem-- The fewer times you have to open and close the waterproof housing, the fewer chances that things would go wrong, I thought. A couple weeks after I was home, I decided to take the battery out and store the strobe. I wanted to make sure that no battery acid had a chance to leak out while the strobe was in storage. However, before opening the housing, I thought that I would flash the strobe to make sure it was still working. The strobe was lying sideways, flat on my outstretched palm. I turned the strobe on and let it charge up and when ready, switched the knob to flash the strobe. B-O-O-M! Yes, it was the ole stick of dynamite effect all over. When I opened my eyes, I saw that the only thing left on my hand was a small chunk of plastic with one of the underwater housing clamps attached. Now, this strobe weighs 6 1/2 pounds [3kg] in air. The explosion blew the back half of the strobe about 8 feet [3m] to my left and smashed the housing against the wall, and blew the front of the strobe to my right, smashing against the wall about 6 feet [2m] away. Was I glad that I was not looking into the strobe when it flashed! I suspect that if I had, I would have lost some teeth and my face would have looked like it had been hit with a baseball bat.

The strobe's instructions mentioned not to store it with the battery inside. I had assumed that the reason for this was the possibility of the battery leaking and destroying the electronics. I wrote the manufacturer about this accident, asking why it happened. The manufacturer said that the battery as it is being used will produce hydrogen gas. After my three weeks of use, plus a couple weeks of storage, enough hydrogen had been produced inside the strobe housing to explode when I fired the flash tube. After this experience, I felt that the strobe manufacturer should state clearly in the instructions that explosions will happen when you use and leave the battery in the strobe. Telling the consumer the reason for certain safety precautions would be even better from a safety perspective. As a charred crispy critter, I certainly felt stupid but lucky.

My guess as to why the all-weather camera exploded was either hydrogen gas from the batteries or acetylene gas was trapped inside the camera and was ignited when the built-in strobe was flashed. I think the same thing happened in the example of the flashgun exploding. It was stored in a waterproof ammo can. This allowed a gas buildup of some type, and thus the explosion.

As a side note, "All batteries decompose their electrolyte into hydrogen and oxygen gasses when charged... The gasses are, therefore, continuously produced and can pose a hazard in buildings [or any type of enclosure] unless they are adequately vented... For any battery plant capacity, NiCd batteries produce 10 to 22 times more hydrogen gas" [than lead-type batteries].[3]

What this means to someone using a rechargeable battery system in equipment, or electronic strobes that have built-in rechargeable batteries, is that one should allow time for the housing to vent any built-up gasses before sealing the charge port and using the unit. Most rechargeable batteries used in underwater strobes are NiCd.

Maybe the lessons to be learned from these examples are:

1. Anytime there is a possibility of acetylene gas building up in a closed airspace and seeping into strobes, flashguns and cameras, then open these devices and let them air-out before using them. In the case of cameras, since we are in a cave environment, all lights can be turned out and the film would not be exposed.

2. In using all-weather cameras, cameras with built-in strobes, and waterproof strobes, do not leave these closed for long periods of time and then use them without first airing them out. What is a "long period of time?" I do not have a precise definition. In the case of the all-weather cameras, between rolls of film within one day of shooting, and air them before starting a day's shooting if they have been stored more than a day, would be a good idea. I think underwater rechargeable strobes could be opened up at the beginning of each day. This procedure should prevent sufficient hydrogen gas from building up from the camera's or strobe's batteries and causing an explosion.

Electronic flash-tube external trigger-electrodes can produce sufficient spark to ignite explosive gasses. Intense light alone can ignite some mixtures, such as hydrogen and chlorine. Acetylene and hydrogen have, respectively, the widest inflammability limits of any gasses listed in the CRC Handbook of Chemistry and Physics (in air, by volume percentage):

Acetylene	C_2H_2	2.5 - 80.0%
Hydrogen	H_2	4.0 - 74.2%

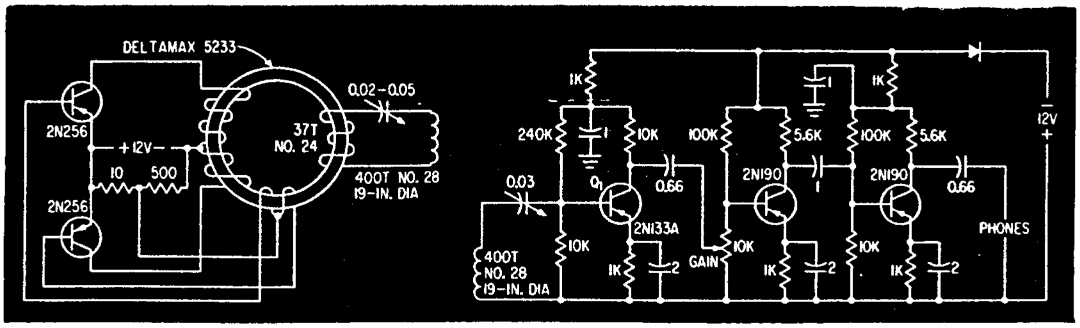
By comparison, the ranges of common fuel gasses are:

Methane	CH_4	5.0 - 15.0%
Propane	C_3H_8	2.12 - 9.35%
Butane	C_4H_{10}	1.86 - 8.41%

References:

1. "Cave Camera Explodes!" Speleonics 14, vol.4 no.2, Feb 1990 p.3.
2. William R. Halliday, MD, American Caves and Caving, Harper & Row Publishers, 1974, "Acetylene Explosions," p.80.
3. M.R. Yenik, "Choosing the Right Batteries for Communications Facilities," Mobile Radio Technology, April 1990, p. 26.

* 207 West Crestland Drive, Austin, Texas 78752



Transmitter (left) generates 2-Kc magnetic field picked up by transistorized receiver (right) located on surface

Mapping Caves Magnetically

Magnetic induction device helps map underground caves and also provides communication with the surface

By E. R. ROESCHLEIN
Sr. Electronic Engineer, U. S. Naval Avionics Facility, Indianapolis, Indiana

INVESTIGATION of underground caves and correlation with local surface topography is simplified by using this low-frequency magnetic induction field direction finder. The transistorized 5-watt 2,000 cps generator feeds a tuned loop and is located within the cave being mapped. The detector is located on the surface where mapping is easily accomplished.

The 2-Kc frequency was chosen since higher frequencies are severely attenuated by rock, soil and water. The mode of transmission is the magnetic induction field, which is attenuated as the inverse square of the distance. Since the distances involved are from 100 to 300 feet, the inverse square law is not too burdensome. The transmitter-receiver described has a range of approximately 400 ft and within this range has sufficient field strength for null determination and ease of communication.

The transmitter, shown in the figure, uses a pair of power transistors to drive a core to saturation in each direction. Base windings are connected to provide feedback for oscillation. The bias network is adjusted so that twice operating current is drawn when the output is shorted (not oscillating). Link coupling is used between the transmitter and the transmitter loop antenna. Series tuning lowers the impedance and allows retuning when changes in frequency occur with battery aging. Initial frequency is determined by magnetic material, number of turns and battery voltage. The frequency decreases as the battery voltage reduces. Total current is 0.6 ampere at 12 v or about 7 w.

The receiver uses a pickup loop antenna similar to the transmitter and is also series tuned. Input transistor Q_1, is a low-noise type and is followed by a two-stage audio amplifier. The stages have a common-emitter configuration with poor low-frequency response to minimize pickup from local power lines. Ample gain is afforded to take advantage of the low-noise properties of the first stage. The current drain is 3 ma.

In operation, the usual Morse code is used for communication with long dashes being used for locating. The surface operator determines the local direction of magnetic flux by rotating his loop with the flux until a null occurs. This is a two-dimensional null and the direction of the flux both in azimuth and elevation can be determined. The transmitted magnetic flux is in the form of circles with the circumference of each circle passing through the transmitting coil. If the transmitter coil is horizontal, there will be one circle of infinitely-large radius that forms a vertical line through the transmitter coil. This line is the one that the surface operator looks for and can then locate the point directly over the cave operator.

Field strength varies as the inverse square of the distance, and since the low-frequency magnetic field is attenuated very slightly as it passes through the layers of rock, soil or water, the strength of the received signal can be measured. The system can be calibrated for distance on the surface and this calibration can be used for depth measurement.

This article in Electronics magazine interested a great many American cavers in "cave radio" as a mapping aid.

VOICES FROM THE PAST

Frank Reid

Thanks to **Ron Johnson** [WA5RON] for suggesting this article and supplying reference material, and to **Angelo George** for the resources of his remarkable library of spelean history.

Nathan B. Stubblefield of Murray, Kentucky, apparently discovered the inductive and earth-dipole principles as used today in "cave radio." He demonstrated wireless voice transmission in 1902, long before radio was practical, using magnetic induction to communicate several hundred feet. His equipment was made of telephone components, and used no amplifiers (which were not invented until 1907). He did not profit from his inventions; numerous articles recount his tragic story.[1,2,3]

The Boy Electrician by Alfred P. Morgan is a classic hands-on introduction to electrical fundamentals.[4] First published in 1913, it became standard in highschool libraries. Chapter 16, "An Experimental Wireless Telephone," describes an inductive communicator nearly identical to that of Stubblefield's 1808 patent (see illustration on the cover of this issue).

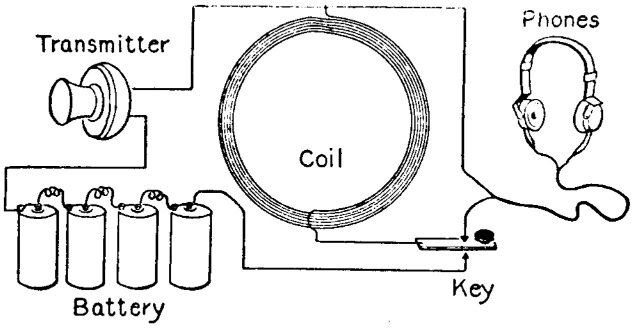


FIG. 237.—The Circuit of the "Wireless" Telephone. When the Key is up, the Phones are connected to the Coil. When the Key is pressed, the Transmitter and Battery are connected to the Coil.

> [From text]: The telephone transmitter and telephone receiver...can be secured from a second-hand telephone. An 80-ohm receiver will serve the purpose, but it is much more satisfactory to use a pair of 1000-ohm radio receivers [earphones].
>
> A battery of...12 volts is required... Storage cells are best for the purpose. Do not hold the key down any longer than is necessary, or the telephone transmitter will become hot.
>
> By making the coils 6 feet [2m] in diameter and placing from 200 to 400 turns of wire in each coil you can transmit speech 300 feet or more... Be sure to keep the coils exactly parallel...

Stubblefield also communicated to a reported range of one mile, apparently by injecting current into the earth between two widely-separated ground rods, and detecting the signal between a distant pair of similar grounds.

Perhaps Stubblefield discovered the earth-dipole effect during his work as a telephone repairman. ("Earth dipole" is the preferred term for communication between ground rods; "earth current" is naturally-occurring current through the ground, associated with aurora, magnetic storms, etc.) Old-style telephones with internal batteries and hand-cranked ring generators (including military field-phones, also modern electronic cave-phones[5]) can operate over a single wire, using earth for the return path. Stories from World War I tell of using field phones connected to pairs of ground rods to intercept enemy telephone traffic along parallel trenches, without direct wiretapping.

When warring governments suspended ham-radio activities during the 1940's, some disenfranchised hams communicated by "ground wave," using audio amplifiers to feed currents into the earth through pairs of ground rods. Ranges greater than one mile were claimed.

Modern electronics-hobbyist magazines occasionally feature articles on earth-dipole telephones.[6,7] Cavers have found them useful; Bill Plummer analyzed them mathematically.[8]

Stubblefield may also have discovered that the earth-dipole and induction methods interact: Alternating current through the ground creates a magnetic field detectable by coils. Conversely, an AC-carrying coil induces currents into conductive earth, which are detectable by ground probes. The well-known interaction is used in geophysical prospecting methods.[9] Cavers who have built baseband audio communicators which use both inductive and earth-dipole modes report that induction works best through dry, highly resistive rock, but earth-dipole provides best communication through very conductive overburden. At one location, the soil in the bottom of a sinkhole was so conductive that magnetic signals from an underground coil were undetectable on the surface, but when the transmitter was switched from coil to probes, it became loud and clear through the surface receiver with coil antenna.[10] British cavers report that inductive communicators sometimes do not work in caves under highly-conductive peat bogs.

The non-amplified devices described above might work as cave "radios." Modern inductive communicators often do not surpass the claimed performance of the old systems. Physics seems to impose severe range limitations on earth-dipole and near-field inductive communications; perhaps long ranges were easier to achieve before the electric power industry introduced enormous AC signals into the earth. Planned experiments using autocorrelation techniques at extremely narrow bandwidths should be interesting.

References:

1. Kahaner, Larry WB2NEL "Who Really Invented Radio--The Twisted Tale of Nathan B. Stubblefield" 73 Magazine, Dec. 1980, p.36.
2. ____ Kentucky Progress magazine, Dec. 1930 p.19 ff.
3. Edwards, Frank Stranger Than Science 1959. Chapter 3: "Neglected Genius."
4. Morgan, Alfred P. The Boy Electrician Lothrop, Lee & Shepherd Co. copyright 1913, 1929, 1940, 1948. 7th printing 1957, p.295 ff.
5. Were, Barry "The Michie Phone" Speleonics 4, p.13.
6. Maynard, Fred "Terraquaphone" Electronics Illustrated, Sept. 1961 p.41.
7. Centore, Mike "Sounds from the Ground" Elementary Electronics May-June 1972 p. 49.
8. Plummer, Wm. "A Cave Telephone" The Baltimore Grotto News v.8 no.5 (reprinted in Speleo Digest 1965).
9. Bosschart, R.A. "Ground Electromagnetic Methods" Mining and Groundwater Geophysics / 1967 L. W. Morley, ed. Dept of Energy, Mines and Resources, Ottawa, Canada. (See also general geophysics texts.)
10. Earl Biffle and Paul Wightman, pers. conversations.
11. O'Connell, Joseph, "A Ground Communications System" Modern Electronics, Sept. 1990 (v.7 #9) p. 16.

GREAT MOMENTS IN EARLY CAVE RADIO EXPERIMENTS

by
Angelo I. George, NSS 7149F [1869 Trevilian Way, Louisville, KY 40205]

INTRODUCTION

The following chronology is part of on-going history research in early radio reception and broadcast from caves. At present, I have found no early examples of wireless broadcast from caves. Induction cave radios made their appearance in the latter quarter decade of the 1950s. Even with cave radios, there has not been any commercial radio broadcast from a cave without the aid of telephone lines. Nor have there been any satellite up-links from caves.

I am especially interested in receiving information on the pre-1926? engineers' experiment in Endless Caverns. Any information on radio experiments conducted in Howe Caverns and Carlsbad Caverns would also be most welcome.

RECORD OF CAVE RADIO RECEPTION EVENTS

19 August 1922 Mammoth Cave (Frozen Niagara Ent.): Roosevelt's Dome
Received WHAS and other eastern radio stations. First radio reception in a cave.

Fall 1922 L&N Rail Road Tunnel, Kentucky(?)
Experiment not conclusive.

21 July 1923 Mammoth Cave (Historic Ent.): Echo River
Received WHAS.

1924? Hudson River Tunnel, New York City

14 July 1924 Mammoth Cave (Frozen Niagara Ent.): Radio Room
Received WHAA, WOS, WLW.

19 July 1924 Mammoth Cave (Historic Ent.): Rotunda
Re-enactment of the 21 July 1923 radio reception. Antenna wire strung from radio to entrance of cave. Not true radio reception.

Late (?) April 1925 Endless Caverns: Arctic Circle and Ball Room
Merl La Voy radio reception in cave.

Pre (?) 1926 Endless Caverns: Arctic Circle
Radio engineers testing radio reception.

1926?-1927? Wyandotte Cave: Throne and Canopy
Received WHAS.

June 1929 Mammoth Cave (Historic Ent.): Rotunda, Audubon Avenue, River Hall etc.
Eve and Keys watershed induction radio experiments.

20 February 1930 Carlsbad Caverns
Eric Palmer radio wave penetration experiment.

3 March 1931 Mammoth Cave (Historic Ent.): Mammoth Dome
Received KDKA via WHAS, a CBS affiliate.

1930?-1940? Howe Caverns
Radio experiment, no information.

RECORD OF RADIO REMOTE BROADCAST FROM CAVES

8 July 1935 Mammoth Cave (Carmichael Ent.): Snowball Dining Room
First live radio broadcast via. telephone hook-up by WHAS.

13 September 1939 Mammoth Cave (Frozen Niagara Ent.): Onyx Colonnade
A walking tour from the Frozen Niagara Entrance to Onyx Colonnade by WHAS. Remote broadcast over telephone lines.

30 October 1940 Endless Caverns
Suspected remote interview and broadcast over telephone lines with Explorers Club members by Lowell Thomas.

7 July 1940 Mammoth Cave (Carmichael Ent.): Snowball Dining Room
Remote broadcast over telephone lines by WLW.

24 August 1940 Mammoth Cave (Frozen Niagara Ent.): Frozen Niagara Formation and Echo River
Remote broadcast by WGRC over telephone lines.

27 July 1940 Great Saltpetre Cave
WHAS live broadcast over telephone lines.

ACKNOWLEDGMENT

Ms. Judith Campbell Turner, Museum Librarian, Milwaukee Public Museum prooved invaluable in supplying information on the museum expedition to Endless Caverns. Mr. Russell Gurnee produced a number of items on the Explorers Club expediton in Endless Cavern and back ground on Merl La Voy. Mr. Gordon L. Smith sharied his knowledge on post card views and his collections on Endless Caverns. Ms. Emily Davis-Mobley supplied the radio post card by Merl La Voy.

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-=-

1990 NSS Convention Electronics Session abstracts:

ERROR SENSITIVITY OF CAVE-RADIO DEPTH MEASUREMENT

Frank Reid NSS 9086

Methods for measuring the depth of a magnetic-induction "cave radio" transmitter are reviewed. The slope of the depth function is determined and used to establish criteria for acceptable error sensitivity: Vertical-null angles between 17 and 70 degrees appear to yield best depth accuracy.

--

AUTOCORRELATION TECHNIQUES FOR CAVE RADIO

Frank Reid NSS 9086

Autocorrelation is a weak-signal recovery technique which should improve the range of low-frequency cave radio, and can be used for data communication. Autocorrelation requires extreme frequency stability which is difficult to achieve underground where standard-frequency broadcasts are unavailable. Autocorrelation theory is reviewed, and simplified techniques applicable to caving are presented.

--

Brian Pease has independently developed a working auto-correlation cave-radio system which has capabilities beyond those of conventional cave-radios. Brian will tell us about it at the 1991 NSS Convention, and hopefully in these pages!

--

Bob Buecher reported further on his last year's presentation on instrumentation at Kartchner Caverns, Arizona. He reviewed many inexpensive electronic thermometers. --

SELF-POTENTIAL SURVEYS

Bruce Bevan *

No, it isn't do-it-yourself psychology; it is a simple and inexpensive geophysical method which might aid your search for cave entrances.

This is also called a spontaneous polarization survey; both are happily abbreviated as SP. SP surveys measure natural voltages at the earth's surface. These voltages can be caused by the slow flow of water in soil or rock. Both sinkholes and rock fissures have been detected by their infiltration of water.

Equipment

It couldn't be simpler and still be electronics. The major expense may be for a good voltmeter. You are going to be measuring in the range of 5 - 50 millivolts and a $10 meter probably will not be adequate. A digital multimeter would be excellent; you will wish one with an input resistance of at least a megohm.

While it might appear that you could connect your voltmeter directly to metal electrodes which are driven into the earth, this may not work very well. Chemical reactions at the metal electrodes could create false voltages.

What you need are called non-polarizing electrodes, and you might be able to make them yourself. Take a small flower-pot of unglazed ceramic and plug the hole in its bottom. Add a bit of distilled water and then enough copper sulfate so that all the blue crystals do not dissolve. Put a copper rod or wire into this solution and you have a non-polarizing electrode. You may wish 2 - 6 of these.

The essential requirements are that the electrical connection goes from metallic copper to a saturated solution of a copper compound. This solution slowly seeps through the ceramic to make contact with the earth. Plaster is also porous enough that it can substitute for the ceramic.

Copper sulfate is available from chemical supply companies, and a pound may cost roughly $20. One possible supplier is:

Hach Company
P.O. Box 389
Loveland, Colorado 80539
phone 800-227-4224

These copper-copper sulfate electrodes are commonly employed by engineering companies in the search for areas along buried pipes where there is corrosion. If you wish to buy the electrodes, they cost about $25 - $50 from a company such as:

Tinker and Rasor
P.O. Box 281
San Gabriel, California 91778
phone 818-287-5259

or:

Harco Corp.
1055 West Smith Road
Medina, Ohio 44256
phone 216-725-6681

Since the SP method is valuable for searching for mineral deposits, the electrodes are also available from geophysical companies such as:

Heinrichs Geoexploration Company
P.O. Box 5964
Tucson, Arizona 85703
phone 602-623-0578

While these copper-copper sulfate electrodes will probably be good for your survey, you may wish also to consider silver-silver chloride electrodes. I understand that changes in temperature affect them less. This type of electrode is commonly used by chemists for making pH measurements and is called a reference electrode. One in particular costs about $100 each and is catalog number N-05899-25 from:

Cole-Palmer Instrument Company
7425 North Oak Park Avenue
Chicago, Illinois 60648-9930
phone 800-323-4340

The last item you will need is a coil of insulated wire; this might have to be long enough to extend the length of your area for survey.

Doing It

The electrodes should be set in the bottom of shallow holes you have dug in the earth, to a depth of a few inches (or about 10 cm). This will allow the electrodes to make a good contact with the naturally moist soil at that depth.

One electrode can remain fixed at one location for the entire survey. This is the reference electrode and a long wire can connect it to the negative terminal of the voltmeter.

If you have more than two electrodes, plant them ahead of time at your locations for measurement so that they will have a few minutes to stabilize in the earth. These measurement points might be spaced at intervals of roughly 10 ft or 5 m.

Connect the positive terminal of your voltmeter to one of these electrodes and read the DC voltage in millivolts. Record your measurements and their locations so that you can later relocate any of your measurement points.

Be careful of buried metal which might cause voltage changes which would be of no interest to you; nearby pipes, in particular, could cause difficulty.

It appears to be possible that the downward migration of groundwater into a cave entrance or fracture zone in the rock might be revealed as an area with unusually low voltage. However, the application of SP to these types of searches is rather new and there are many unknowns. <u>Your own investigations could be a big help in discovering how and where to try this technique.</u>

[emphasis added. --ed.]

Learning More

This has been a brief introduction to SP surveys. Should you wish to learn more about the

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* P.O. Box 135, Pitman, New Jersey 08071

details of doing these surveys, there are two books which discuss SP; pages 80 - 97 in:

Mining geophysics, 2nd ed., by D.S. Parasnis, Elsevier, 1975, and pages 458 - 499 in: Applied geophysics, by W.M. Telford and 3 others, Cambridge Univ Press, 1976.

Many practical points will be found in: The self-potential (SP) method: an inexpensive reconnaissance and mapping tool, by J.C. Wynn and S.I. Sherwood, Journal of Field Archaeology, summer 1984 (vol 11, no 2) pages 195 - 204, and in: Spontaneous polarization associated with porphyry sulfide mineralization, by C.E. Corry, Geophysics, June 1985 (vol 50, no 6) pages 1020 - 1034, and in: The self-potential method in geothermal exploration, by R.F. Corwin and D.B. Hoover, Geophysics, Feb 1979 (vol 44, no 2) pages 226 - 245, and in: A guide to prospecting by the self-potential method, by S.V. Burr, Ontario Geological Survey Misc Paper 99, 1982, which is available from:

Ministry of Government Services
Publications Section, 5th floor
880 Bay Street
Toronto, Ontario M7A 1N8
phone 800-268-7540

Some time this year, a very complete introduction to SP surveys should be published as:

The self-potential method for environmental and engineering applications, by R.F. Corwin, as a chapter in the book: Investigations in geophysics, no. 5, vol. 1, and available (for $130!) from:

Society of Exploration Geophysicists
P.O. Box 702740
Tulsa, Oklahoma 74170
phone 918-493-3516

A detailed look at factors which can affect an SP survey are given in: Self-potential variations with time and their relation to hydrogeologic and meteorological parameters, by K. Ernstson and H.U. Scherer, Geophysics, Oct 1986 (vol 51, no 10) pages 1967 - 1977.

If you have questions about these surveys, please write me and I will try to help. While I have done several SP surveys, they have all been for archaeological applications and never the search for caves.

Conclusion

This is a type of geophysical survey which is a good one for you to experiment with. You might first do tests at several locations where you know there are cave entrances.

SP measurements are typically rather irregular from point to point. I have wondered if larger-area electrodes could reduce this; a larger size might also allow the electrodes to be set directly on the surface, without a need for digging a hole.

Of course, SP surveys are rather a gamble. The technique could turn out to be impractical or misleading, but it could also work very well.

Good hunting!

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compiled by Bruce Bevan

[Other bibliographies and references appear in Speleonics issues 2, 5, 8, 10 and 14.]

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(5 vector measurements determine orientation and location)

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Federal Highway Administration FWHA-IP-81-3, (Environmental Exploration, Morgantown, W Va 26505), April 1981
(good annotated bibliography)

Lange AL. Cave detection by magnetic survey. Cave Notes, p 41-54, vol 7, no 6, Nov 1965
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IEEE Trans Geoscience Remote Sens, p 182-93, vol 28, no 2, March 1990
(estimate dipole moment and location from 2D map)

Owen TE. Detection and mapping of tunnels and caves. p 161-258 in Developments in geophysical exploration methods, Fitch AA (ed), Applied Science Pub, 1983.
(resistivity, gravity, borehole surveys)

Lowry T, Shive PN. An evaluation of Bristow's method for the detection of subsurface cavities. Geophysics, p 514-20, vol 55, no 5, May 1990
(models show that the depth limit is approx the same as the size of the cavity)

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Van Nostrand Reinhold, 1978
(auto and power line noise LF - VHF)

Watkins JS, Godson RH, Watson K. Seismic detection of near-surface cavities.
US Geological Survey Prof Paper 599-A, 1967
(oscillation and refraction delay and attenuation reveal cavities)

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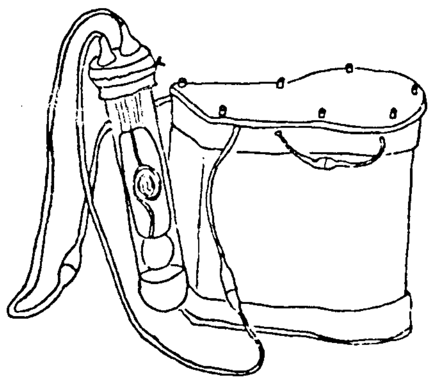
Ed. note: Bruce Bevan is a consulting geophysicist. See Speleonics 14, p. 13.

FRENCH ELECTRIC MINE-LAMP USED IN 1869

Angelo George contributed a fascinating historical article on mining lamps by **Chuck Young** from Potomac Caver 13(1)4-7, (2)13-17, reprinted in Speleo Digest 1970, pp. 302-305.

... Some mines had constant problems with gas... Safety lamps were devised to prevent explosions, or to detect gasses... **The first electric safety lamp was made in 1869 (no misprint).** [emphasis added --ed.]



"Photo-Electric Lamp invented by Dumas and Beniot prior to 1869." Angelo George saw an example of this lamp in the Museum of Materials and Arts in Paris, but does not remember whether it was incandescent or gas-discharge. French experiments with platinum-filament lamps predate Edison's 1879 lightbulb.

Young's article includes references from Scientific American, February 9 and February 23, 1895, about the invention and production of calcium carbide, and reports that Sci. Am. ran many articles about carbide and acetylene over the next 15 years.

See also "Electric Caving Before Lightbulbs or Carbide" by Frank Reid, SPELEONICS 6 (v.2 #2) p. 6.

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INTERESTING REFERENCES

ELECTROMAGNETIC EARTHQUAKE-PRECURSORS?

On page 1562 of the Dec. 22, 1989 issue of Science magazine, a discussion of the Loma Prieta [California] earthquake mentions an interesting correlation made by Antony Fraser-Smith and colleagues from Stanford: radio background noise activity in the 0.01 to 10Hz range increased 12 days before the quake. 3 hours before the quake, it was 30 times greater than the previous level. (There was a drop 1 day before the quake.) There was nothing like this during the 2 years of operating this low-frequency broad-band receiver, studying sun-related radio noise that interferes with submarine communications.) There is a picture of either the receiver or the antenna on page 1563. --**Albert Boulanger**

See also Scientific American, April 1990 p.38. --ed

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Rakes, Charles D. "Build a VLF Transmitter and Receiver" Popular Electronics, July 1990, p.29.

Frequency is below 10 kHz. This project is unusual in that it uses E-field antennas instead of coils. Range is said to be 1/4 mile (500m) with transmitter connected to 120-foot (40m) long-wire antenna.

O'Connell, Joseph. "A Ground Communications System" Modern Electronics, Sept. 1990 (v.7, #9), p. 16.

This article describes baseband audio communication through the ground, using amplifiers connected to matching transformers and pairs of widely-spaced ground rods, or ground rods and water pipes. The article includes frequency-response curves for this system, and suggests using equalizers to maximize range.

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Suga, Nobuo "Biosonar and Neural Computation in Bats" Scientific American June 1990 p. 60.

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Spangler, H.G. "Detecting Lesser Was Moths Acoustically" Gleanings in Bee Culture, April 1985 p. 207.

This circuit for detecting 100-kHz pulses from insects is unusual in that it does not use the heterodyne principal. Amplifiers (one FET and two op-amps) are followed by an envelope detector (diode). It is probably adaptable to bat studies.

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Warner, Ken. "Radio Waves That Work Underwater" Popular Science, May 1965.

This article includes few details, but says that "hydronic waves" propagate at right angles to radio waves.

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Add another name to the list of obscure underground-radio pioneers. "The Rogers Underground Wireless" in Electrical Experimenter magazine, March 1919 (published by Hugo Gernsback) describes underground/underwater radio experiments of **J. Harris Rogers**. He achieved ranges of many miles, using conventional radio equipment with long, insulated wire antennas buried 1-3 feet in the ground. Wavelengths were greater than 600 meters. The article says that Rogers' methods were kept secret and used for submarine communications during the 1914-1918 war.

Previous three articles contributed by **Craig Daskalakis**.

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Campbell, G.S. and Unsworth, M.H. "An Inexpensive Sonic Anemometer for Eddy Correlation" Journal of Applied Meteorology v. 18, August 1979.

Ultrasonic transducers and phase-locked loop detect very low wind velocities. The circuit can be built from about $20 worth of Radio Shack parts. It has no moving parts, is directional, and low-powered. It appears useful for infrasonic studies including cave winds. Mouser Electronics sells weatherproof transducers. Copy of article available from Frank Reid for SASE.

[contributed by **Mark Belding** N9GPA]

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from sci.electronics:

The November '89 issue of Radio Electronics showed how to tap two voltages from the Radio Shack Electronic Car Compass to provide heading information for a computer. This compass costs $50.

For about $300 you can get a gimballed, dampened flux-gate with RS232 out (a-la NMEA standard) from a marine supply house such as West Marine.

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THE WET NOODLE FIELD PHONE

Paul Johnston - KA5FYI *

The Wet Noodle Field Phone was designed and built by myself as a potential communication tool for cave divers in a repetitive sump-diving situation. The Wet Noodle was designed as a lightweight, low-cost, simple and easily-deployable field phone system.

What does this field phone system have in common with a wet noodle? Besides the abovementioned four qualities, its transmission line is light and flexible, but not very durable.

HOW TO OPERATE

The Wet Noodle consists of two black boxes, two 6-volt batteries, two electronic telephones, and two spools of 1000 feet of 24-gauge (0.511mm), 2-conductor speaker wire with quick-disconnect connectors.

We will refer to each of these black boxes as unit one and unit two. Both are operationally the same. These units each have two switches (#1 and #2) and two LEDs (Light Emitting Diodes) called LED #1 and LED #2. The top of the unit is the area above the switches in the direction of the binding posts where the transmission line is connected. The bottom of the unit is opposite the end with the binding posts.

Basic understanding of operating procedures can be learned and practiced within one minute:

1. CALL WAITING - To wait for a call, to be able to receive a call, or once you have finished a call, <u>ALWAYS</u> place both switches in the <u>DOWN</u> position.

2. TO CALL - Put both switches in the up position: The second unit will buzz and both LEDs will light. You will hear in the earpiece the second unit buzzing if its switches are in the correct position. If no one answers, put both of your switches in the down position.

How well the person calling hears the buzzing tone in the earpiece depends on the electronic handset. On one of mine, I can hear the tone very well; the other, very faintly. Anyway, if you can hear the tone with your handset, then you know that the second unit is positively buzzing.

3. TO ANSWER - If you hear a buzz and see both lights, or see any lights, then you have a call. To answer, place <u>BOTH</u> switches in the <u>UP</u> position. After finishing, place both switches in the down position to be able to receive another call.

ASSEMBLY

1. Lay out the speaker cable. Do not step on or allow it to rub back and forth on rocks; do not pull hard; keep away from sharp objects and do not lay any heavy objects on cable. Do not shut a door on the cable.

2. Connect transmission line to connectors on the binding posts at the top of the unit. Use rocking motion to connect, and do not completely push together for reason given above.

3. Insert modular phone plug of phone into phone jack at the top of the unit.

4. Place both switches of the unit in the down position.

5. Connect battery to unit by clipping the alligator clip with the red wire to the positive terminal of the 6-volt battery, and the black wire to the negative terminal.

6. Wait for call.

The switches could be in a variety of positions other than ones shown in the "How to Operate" section. To learn the meaning of these, refer to the truth table.

CONSTRUCTION

The size of the box was primarily determined by the size of the transformers that I had on hand to use as audio chokes. The secondary windings were used to prevent the audio from being shorted through the battery so you could hear the other person. One transformer was a 18-20 VAC wall transformer and the other was a 12VDC wall-plug battery charger. The wall-plug prongs were covered with electrical tape, wires connected to the battery, and silicone seal was used to glue these transformers to the bottom corner of the box.

If you use a DC battery charger, connecting the positive battery wire through the secondary windings will only work in one direction because the charger contains a diode.

I tried secondary windings of various audio transformers and they all work to a degree, but I found that the best volume was achieved with transformers approaching the one the parts list. If you find a smaller choke to your liking, then the size of the box could be reduced.

The telephone wall-jack was bolted to the bottom of the box, and a small hole cut to allow the modular plug to be inserted.

Holes were drilled in the cover for toggle switches, LEDs and holders, and binding posts. Appropriate connections were made with small wire, point-to-point soldering and wrapping some wires under the screws of the telephone wall plug. A hole was drilled in the side of the unit for the sound port of the piezo buzzer. The buzzer was glued into the inside of the box against the sound port, and wires connected to the circuit. Finally, holes were drilled for the external battery wires. Alligator clips were connected to the red and black wires. These clips were used so that they would connect to many different types of battery terminals. A few wraps of tape were applied to battery wires immediately inside the box for strain relief, and a knot was tied in the battery cable on the outside the box to prevent pushing the battery wires inside the box to store them: If this is done, then some small wires on the inside would eventually be broken.

Male and female pronged connectors were attached to the binding posts so that polarity will be correct between units. The two 1000-foot spools of cable were prepared with connectors, with plugs alternating on each end as described above.

A means of spooling-out and retrieving the wire will have to be made. Whether to use one or several spools must be considered: In cave diving, the weight and bulk of the wire will determine the ease of installation.

A waterproof means of transporting the communication unit underwater will have to be devised.

PAY ATTENTION TO THIS! This list is important to the care and feeding of the Wet Noodle:

1. Make sure that the battery polarity is correctl, else both batteries will be working against each other.

* 207 West Crestland
Austin, Texas 78752

2. Do not push the battery cable back into the unit to store the battery wire, or you will break the tiny wires inside. Do not untie the knot in the battery cable next to the unit to help prevent this.

3. Attach the battery only to the battery clips, not to the transmission line binding posts at the top of the unit. Doing so will short the audio through the battery.

4. Tighten the transmission wire connectors gently. If you tighten sufficiently to make the entire binding post rotate, a small wire will be broken.

5. The quick-connectors on the binding posts on each unit are of opposite sex for each polarity on each unit. For example, there is a male prong on the positive post (red) on one unit and a female socket on the positive terminal of the second unit. This is necessary to keep the polarity of the wires correct (positive voltage to the red binding post of each unit and negative voltage to the black binding pot of each unit. All connectors wires are not manufactured to be color coded the same. If you take a connector off or replace it with a new connector, be sure to heed proper polarity.

6. If a connector breaks off the end of a transmission cable, the insulation can be stripped and inserted into the binding posts. Make sure the polarity is correct. One wire is copper color and one is silver color. If you hook up and try to ring the other party and cannot hear the buzz in your earpiece, then the wires are backward. Reverse them, and you should hear the buzz.

Notice also that the connector terminals are reversed on each end of the transmission cable. One one end of the copper colored wire is a male prong and on the other end of the copper colored wire is a female connector and vice-versa for the silver colored wire. This construction helps keep the polarity correct between the two black boxes.

7. If the transmission line breaks, splice it back, observing polarity: copper wires together and silver wires together.

8. Do not use any field phone above ground during an electrical storm. Lightning could induce dangerous voltages on the transmission line.

TECHNICAL NOTES

1. All electronic phones are not equal. Some you will not work on Wet Noodle system. Basically, you need a light-weight unit that draws little current. None of the buttons functions in relation to the other phone. The phone is either on-hook or off-hook. You can punch the tones to get an idea of the condition of your battery. The entire system will operate on only one battery, with the disadvantage that the person without a battery cannot make the other unit buzz. A time schedule to receive calls is always desirable, in case of battery or ringer failure.

2. If in a noisy area where you cannot hear the buzzer, watch the lights. If you are being called, there will be one or two lights depending on how the switches are set. If both units are operating correctly and switches are set in call-waiting mode, then you will see no lights.

3. Switch #1 on the upper left is used to buzz the other unit or hear the other person talk when it is in the upper position. In the down position, it will cause the unit to buzz when paged from the other unit.

4. Switch #2 is the battery on/off switch.

5. Each single 1000-foot strand of 24-gauge copper wire has about 35 ohms of resistance, and weighs about 5 pounds.

6. When both units are talking with each other, about 40 milliamps flow through 2000 feet of wire.

7. Six-volt spring-terminal lantern batteries should give many hours of operation.

GENESIS

The development of the Wet Noodle came about during a conversation with Jim Bowden, noted cave diver, about cave diving in long sumps in Mexico. Sometimes there are extended underwater passages of 1000 feet or more between air-filled chambers leading to the next sump. The divers are separated by a long distance from the support crew. Jim related how his partner had experienced a primary light failure, and if they had had some means of communicating with the support team, then another light could have been brought to them, making the exploration much easier.

This conversation made me think about developing a field phone system that could be easily deployed by cave divers, using low-cost and readily-available parts. I wanted the system to be easy to use, and have visible and audible call-alerts.

Jim said that he thought such a system would come in very handy for an upcoming exploration trip in Mexico, and asked if I could have the system ready for a prior cave-diving training session to Honey Creek Cave (Comal/Kendall county, Texas), the longest cave in Texas.

In September 1989, the cave-diving students were assembled at the original entrance to Honey Creek. The first 1000 feet of the cave is an underground stream that is excellent for cave-diving training. The long stretch can be dived, and if there is a problem, you can come to the surface and talk.

We were concerned that a single 1000-foot spool might not reach the first beach area.

Jim deployed 100 feet of cable from the first spool and connected it to one communication unit at the entrance. He then took the second spool and swam the first 100 feet, connected the two lines, then proceeded the entire underground stream to the first beach area, about 1000 feet in. He rang the entrance and found that communication quality was "clear as a bell." Even a near-by cave diver spoke out that she wanted to order a pizza and this was heard by the entrance personnel.

This exercise proved that the system works through 2000 feet of wire with one connection made underwater. The communication cable could be seen underwater, and occasional wraps were made on underwater projections to hold the communication line in place. I am sure much longer runs of communication able could be used if needed. Another alternative would be to "leapfrog" spools of wire as exploration continued and base camps were moved further into the cave. This would keep the amount and weight of the communication cable to a minimum.

The Wet Noodle will be set up for about one week in some extensive underwater passages in Mexico. Any short-comings will certainly make themselves known at that time. Transportation of the communication units were done underwater by means of a waterproof metal cylinder that had formerly held some type of rocket ammunition. Jim had wanted to test this transportation system in Honey Creek for use in transporting bedrolls and supplies to under-ground campsites in the upcoming cave diving expedition to Mexico. Long live the Wet Noodle.

References

1. Sam Allen, "Build the DTMF Field Phone," Popular Electronics, Feb. 1989, Vol. 6, No.2, p.41.

2. John Halleck, "Summary of the Cave-Rescue Telephone Project," Speleonics 12, vol. 3, no. 4, April 1989, p.10.

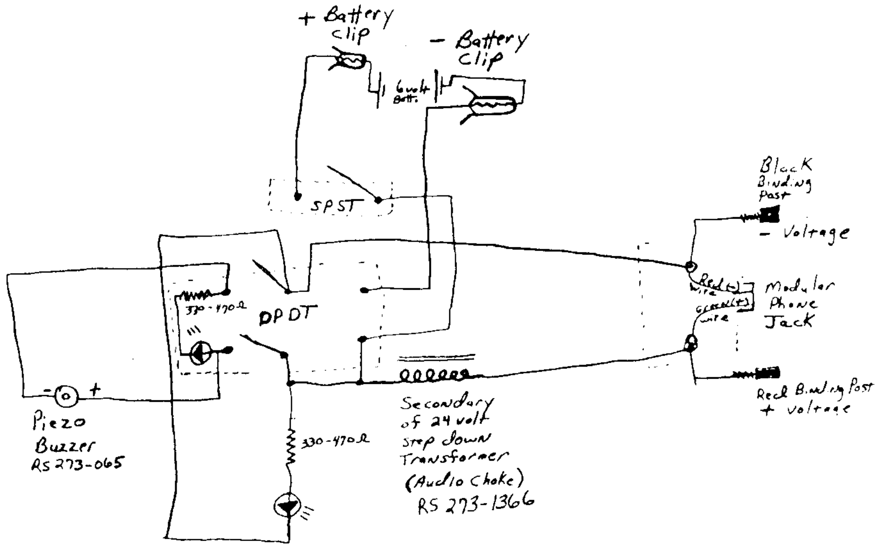
3. Frank Reid, "Phone Patch Connects Cave to Hospitals," Speleonics 7, Spring 1987, vol.2 no.3, p.17.

4. Barry Were, "The Michie Phone System," Speleonics 4, Spring 1986, vol.1 no.4, p. 13.

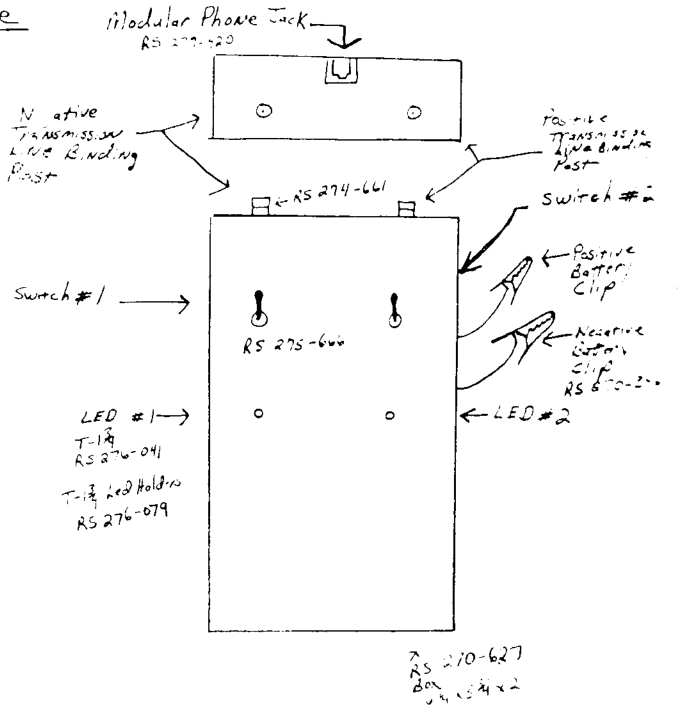
5. Contributed by Jim Quinlan, "Earth Return Telephone for Cave Rescue," a summary, Speleonics 11, Nov. 1988, vol.3 no.3, p.14.

SUGGESTED PARTS (each unit)

QTY.	RS = Radio Shack part number
1	RS 279-420 Modular phone wall-jack
1	RS 270-627 Project box - 6-1/4 x 3-3/4 x 2"
2	RS 274-661 Binding posts
2	RS 276-079 T-1 3/4 LED
2	RS 276-079 T-1 3/4 LED holder
2	RS 275-666 DPDT toggle switches
2	330 to 470 Ohm 1/4 watt resistors
1	RS 273-065 Piezo buzzer
1	RS 273-1366 25.2 VAC step-down transformer
1	6 volt spring-terminal lantern battery
1	Electronic phone handset



The Anatomy of A Wet Noodle



CHARGING SEALED LEAD-ACID BATTERIES

by William K. McFadden
(bill@videovax.tv.tek.com) Tektronix TV Measurement Systems, Beaverton OR
[adapted from computer newsgroup sci.electronics, 8 Dec 1989]

> What is an appropriate fast-charge rate for sealed lead-acid batteries?

Usually 0.2C (current equal to 20% Ampere-hour capacity) max. for gel-cells, e.g., 1.2 Ampere for a 6 Amp-hour battery.

> Is it ok to trickle charge them in a burglar-alarm application?

Yes. Use 2.35 V/cell, e.g., 14.1 volts for a 12V battery. (Some people like 2.3 V/cell, giving 13.8 volts.)

> What does the discharge curve look like?

At 25° C, the open-circuit voltage is about 2.18 V when fully charged, declining linearly to 1.98 V when 10% of capacity is left.

> How should a fast charger know when to turn off?

If the charger is a regulated supply, it will shut off by itself as the battery reaches full charge. A constant 2.35 V/cell charger will recharge a battery to 90% within two hours, and the battery can be left float-charging at 2.35 V/cell indefinitely to maintain full charge. Extremely dead cells may go above the .2C rate if fed from a 2.35 V/cell charger. Going above this rate may cause excessive outgassing, which will eventually dry out the electrolyte. It is best, therefore, to limit charging current to .2C for gel-cells (which will result in a longer recharge time). Wet cells can be recharged at higher rates.

> Do lead-acids have the memory problems of NiCads?

No. However, it is important to fully recharge lead-acid cells, with 2.35 V/cell optimum for batteries that are cycled once per week or less, and 2.45 V/cell for batteries that are cycled once per day.

> Is it ok to leave them flat?

No. The minimum voltage allowed during discharge is 1.6 V/cell, and lead-acid batteries should not be allowed to self-discharge below 1.8 V/cell. If allowed to discharge below 1.8 V/cell while in storage, the battery will take longer than normal to recharge, and the next discharge cycle cannot deliver the rated capacity. Subsequent cycles, however, will result in an increase in capacity to the rated capacity.

If you let a lead-acid battery discharge completely to 0 volts, the electrolyte turns to water and is therefore not conductive. You can remedy this, however: Using a constant-current source, charge the cells at a .1C rate. This may require as much as 20 V/cell if the cell is extremely dead. When the voltage falls to about 2.5 V/cell, switch to a constant voltage, 2.35 V/cell charge until charging current levels off (e.g., reaches a minimum).

> What is the best condition for storing them?

Since they're sealed, humidity is not a concern, and gel-cells may be stored or used in any position. As with all batteries, the rate of self-discharge is a strong function of temperature. After 5 months of storage at 20°C, the typical battery will have 60% capacity remaining. At 40°C, however, the battery would be fully discharged after 5 months.

> And out of curiosity, how do the corresponding NiCad (nickel-cadmium) systems work?

Standard chargers normally charge at 0.1C for 14 hours, since this allows a very simple charging circuit-- Batteries can be overcharged at .1C for extended periods without drastic reductions in life. Fast chargers usually sense temperature, starting with currents as high as 4C, and tapering off as the cells get warm. I have also heard of fast chargers using temperature-compensated voltage detection, and detection of the voltage reduction that occurs after full charge has occurred. Nicad batteries in memory-backup applications are usually trickle-charged continuously at 0.002C to 0.1C, constant current.

For a cheap charging circuit for lead-acid or nicad batteries, see LB35 in the National Semiconductor Linear Applications Handbook.

Most of my information comes from "Summary of Battery Chemistries," Maxim 1988/89 Seminar Applications Book, parts of which are quoted above. Additional information about reviving dead gel-cells came from an article posted by **Jan Steinman** to sci.electronics on 9/3/87.

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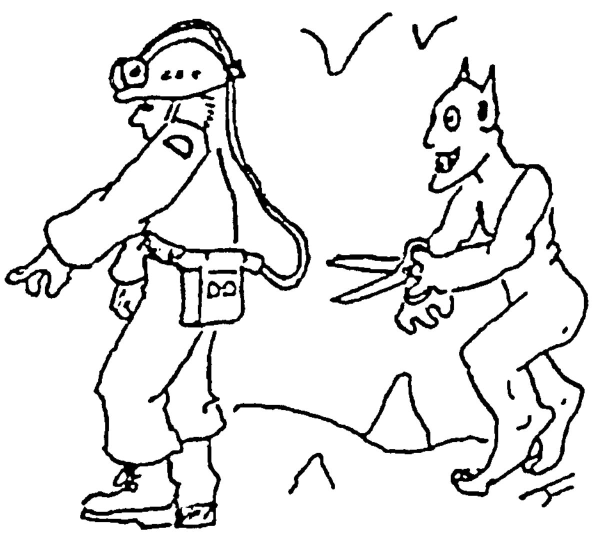

[cartoon by **Jerry D. Fuller** from DC Speleograph, April 1990]

Ed. note: After seeing the Nullarbor Dreaming video (reviewed in Speleonics 14), I wrote to Ron Allum requesting details of the very caveworthy-looking audio transducers used on his cave radio. His reply:

UPDATE ON INDUCTION CAVE RADIO (Previously described in Speleonics 4)

by Ron Allum *

The radio described in Speleonics 4[1] was used on the 1983 Cocklebiddy Cavediving expedition. It transmits and receives voice frequency, using large-diameter loops. This is possible on the Nullarbor because the caves have large chambers, the above terrain is flat and no trees, and portability of the radio is not a factor to be greatly concerned about. The nearest power grid is about 500 kilometres away, leaving the Nullarbor "electrically quiet." Similar loops are used for both surface and underground radios to transmit and receive accordingly; the loops are positioned one above the other, as determined by first using RDF. Each loop consists of two wires, 100 metres in length of 1 mm^2 cross-sectional area, these being laid to form two turns of the largest area possible.

The radio has since been upgraded and was successfully used on the 1988 Pannikin Plain Cavediving expedition.[2] The preamp was changed to a balanced low-impedance current input stage followed by a balanced-output car radio loudspeaker amp as used previously. These amps are used for both receive and transmit by switching the loop and voice transducers to the amplifiers' input and output terminals appropriately. A level (volume) control is also switched in circuit between the amplifier stages when receiving.

The voice transducers are also different. I used telephone-earpiece inserts (magnetic rocking-armature type) on the updated radio. I connect a heavy-duty screened one-pair cable to the insert; I solder the screen to a solder lug and connect it to the aluminium case of the insert using a short self-tapping screw and a star washer. The signal wires are connected to the signal terminals (which, on the insert I obtained, are insulated from the case, i.e., balanced output). Another screw secures the cable sheath to the insert, using a "P"-type clamp. A piece of insulating tape is used to cover the holes in front of the insert. The insert is then dipped into a liquid latex solution (natural rubber dissolved in an ammonia solution - I think) available from rubber stores as a modelling solution. This is allowed to air-cure for 24 hours, then repeated 3 to 4 times to build up a resilient coating. I connect 2 inserts in parallel: One is used as a throat mic where it is placed against the neck adjacent to the larynx, avoiding any airspace between transducer and skin, whilst the other is used as an earpiece placed adjacent to the ear. The impedance is modified by adding series resistance to adjust the preamp gain when transmitting and to limit the voice current to the voice transducers when receiving.

The idea of using low-impedance current-input preamps and waterproofed voice transducers was to improve the reliability of the radio. As fate had it, the Pannikin Plain expedition was deluged by an enormous quantity of water, causing the cave to collapse trapping 13 people inside.[2,3] This radio was subsequently used to coordinate the rescue that followed. These ideas may be useful to other cave radio designers/experimenters.

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References:
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1. Allum, Ron "Cave to Surface Communications" Speleonics 4 (v.1 #4) Spring 1986 p.8.

2. Allum, Ron "Australian Rescue Uses Cave Radio / The Pannikin Plains Cave Diving Expedition 1988: Incident Report." Speleonics 12 (v.3 #4) Apr. 1989 p.2

3. _____ Australian Cave-Diving Video (review) Speleonics 14 (v.4 #2) Feb. 1990 p.2

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NEW SUPER HIGH-BRIGHTNESS LEDs

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Hewlett-Packard has recently introduced several new super high-brightness light-emitting diodes. The new transparent-substrate AlGaAs red LEDs feature brightnesses of several candelas (cd), an improvement of about 1000 over most garden-variety LEDs! These parts could be of interest to cavers interested in high-reliability, very low-power emergency backup lights.

Along with the data sheets I requested, I received a sample of the HLMP-8103 in the form of a small flashlight powered by two AA cells. I took this along on my last caving trip and found its light lacking for illuminating the far side of 100' wide passage, but more than adequate for lighting my immediate area. The red light is a bit strange at first, but my eyes quickly adapted. I would have had no problem exiting the cave on the 3 cd light of this one single LED. The flashlight sucks current at the outrageous rate of 16 mA. Now let's see, a Wheat lamp eats about 500 mA on low beam and lasts about 10 hours. This would power 3 similar LEDs (in series, to drop close to 6 volts) for about 300 hours providing almost 10 cd of light. This is roughly equal to a carbide lamp operating continuously for almost two weeks! The 8150 would provide five times more light for the same current draw, but at a greater cost and smaller viewing angle.

Here is a quick comparison chart. Right now, the 8103 offers the most light for the buck.

LED part #	intensity (cd)	viewing angle (degrees)	price	price per cd
HLMP-8100	.7	24	$0.65	$0.93
HLMP-8102	2	7	0.80	0.40
HLMP-8103	3	7	1.00	0.33
HLMP-8104	4	7	3.50	0.87
HLMP-8150	15	4	12.20	0.81

Notes: Intensity is at 20 mA, wavelength is 637 nm, price is for 1-99 for 8150 and 1-999 for the others.

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FALSE CENTER FOUND IN UNUSUAL RADIOLOCATION

Frank Reid

During a cave-radiolocation at Horn Hollow in Carter Caves State Park, Kentucky, the surface search began at lower elevation than that of the underground transmitter, causing confusing results until the error was discovered: A false "Ground Zero" was found parallel to the transmitter instead of above it.

Having acquired the signal, I walked down a dry stream bed, doing conventional horizontal direction-finding. As the nulls became perpendicular to the stream, I climbed the steep hillside in dense vegetation, still seeking horizontal nulls, but also taking vertical nulls. I found a spot where the magnetic field appeared to be vertical for all horizontal orientations of the receiver coil's axis, but something seemed wrong-- Despite very strong signals, the vertical nulls were not sharply defined as they should be at Ground Zero, the point directly above the transmitter. The vertical angle did not change rapidly with distance from Ground Zero as experience told me it should for such a shallow depth.

Moving away from that location, parallel to the stream bed, I double-checked the horizontal nulls and found the true Ground Zero about 40 feet higher in elevation. The depth indication at the new point was 40 feet +/- 3 inches. The first location had been a false Ground Zero <u>parallel</u> to the transmitter instead of above it.

The cave had not been mapped by conventional methods, and cavers' estimates of the surface location were tenuous. The search began near the range limit of the equipment; the entire locating and depth-measuring processes took 40 minutes.

The magnetic field re-enters the ground (vertical angle > 90°) at horizontal distances from Ground Zero greater than 0.71 times the transmitter depth. This "backside" of the field, or re-entry zone, is usually recognizable because signals are weak and vertical nulls very indistinct.

In this particular case, starting at an elevation unexpectedly below the transmitter, vertical angles in the re-entry zone were <u>less</u> than 90° (Fig. 1). That effect, plus strong signals from a depth of only 40 feet, caused me to find an erroneous location. The lessons learned are that one should always visually identify the area of converging horizontal nulls before using vertical nulls to refine the location[1], and that radiolocations in unmapped caves may be more difficult than expected.

Reference:

1. Reid, F. "Electronics in Caving," <u>Caving Basics</u>, T. Rea, ed. NSS 1988.

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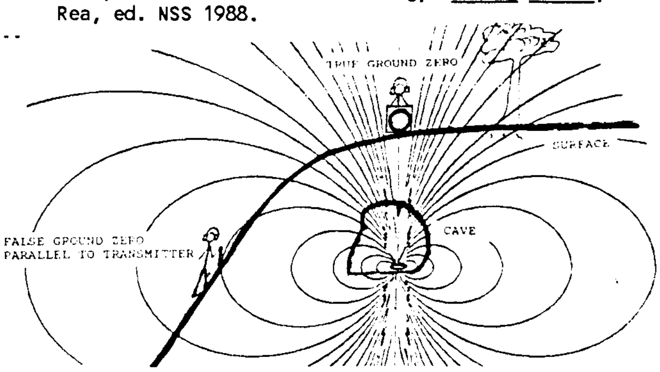

Vertical magnetic field parallel to transmitter may mislead a cave-radio receiver operator who is at lower elevation than the transmitter.

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