speleonics 15

OCT. 1990

volume IV number 3

Fig.1.

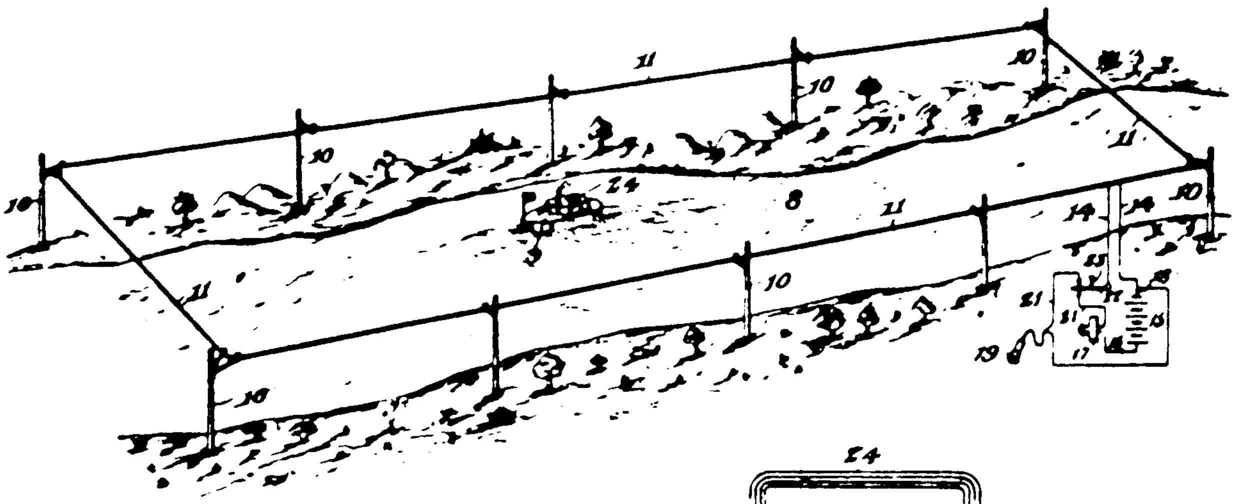
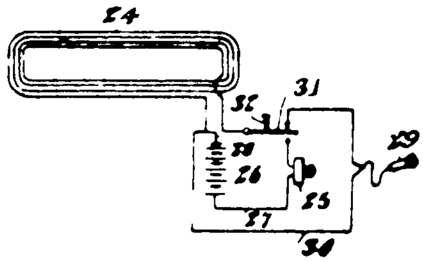


Fig.2.



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."

CONTENTS

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. Flash-floods 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 flash-gun.[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%

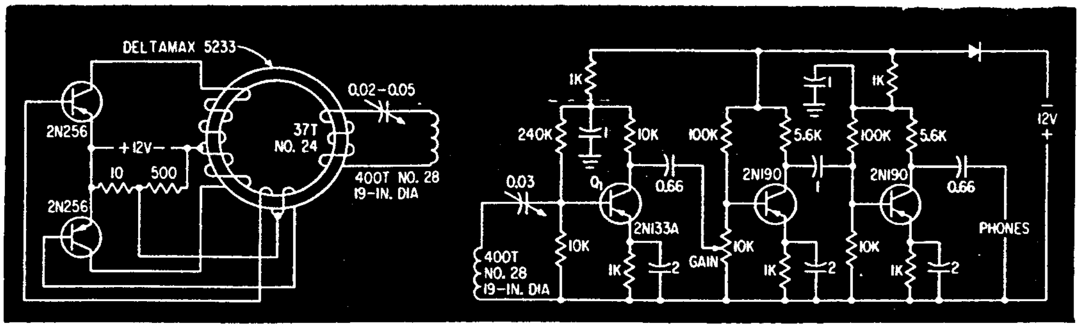
By comparison, the ranges of common fuel gasses are:

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).

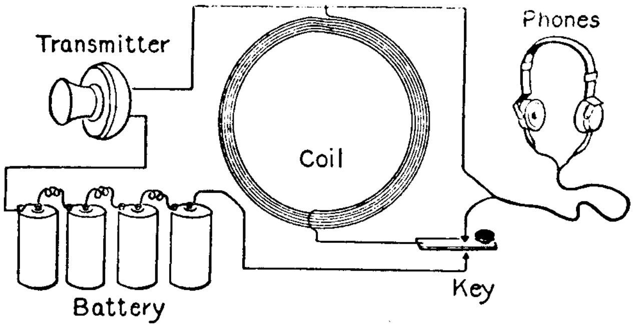


FIG. 227.—The Circuit of the "Wireless" Telephone. When the Key is up, the Phones are connected to the Coil. When the Key is pressed, the Transmitter and Battery are connected to the Coil.

> [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:
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2. ____ Kentucky Progress magazine, Dec. 1930 p.19 ff.
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