

speleonics 6

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1986

"BETTER CAVING THROUGH ELECTRICAL STUFF"

VOLUME II NUMBER 2

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SPECIAL ISSUE ON LIGHTING



« Axel! Axel! est-ce toi? »

SPELEONICS 6

Volume II, No. 2, Fall, 1986

SPELEONICS is the quarterly newsletter of the Communication and Electronics Section of the National Speleological Society. Primary interests include cave radio, underground communication and instrumentation, cave rescue communications, 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, \$6.00 elsewhere**. Send subscriptions to section treasurer **Joe Giddens** at the address below. If you have a radio call sign or NSS membership number, please include them when subscribing.

Overseas subscription can be paid in U.S. "paper" dollars in the mail. We are informed that an international money-order costs as much as the

subscription! Several have sent cash without problems.

Editorship rotates among the officers. **Volunteer individuals or groups are invited 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** are mailed to NSS offices and sections, the U.S. Bureau of Mines, U.S. Geological Survey, and the Longwave Club of America. Due to the rules and economies of bulk-mailing, a number of promotional copies are sent to NSS Grottos, NSS members, and potentially-interested people, on a random irregular basis. We will send one free sample issue to anyone recommended by a Section member.

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(C-64 graphics by Dan Fox)

Most newsletters suffer from Creeping Administrative Trivia which crowds out real news and articles of lasting interest (See, for example, the August 1986 NSS News). We have plenty of "real" material, so the editorial has been kept short!

We salute our 24 Section members who live outside the U.S. (representing Australia, Austria, Belgium, Canada, Great Britain, New Zealand, Sweden). Their enthusiasm is exemplary, and their cave-electronics are innovative and advanced. Get with it, Yanks!

ANNOUNCEMENTS

Caving Publications Updated: The NSS publication, **Caving Basics**, is now being re-edited by **Tom Rea** to be printed in 1987. **Manual of U.S. Cave Rescue Techniques** is being updated by **Steve Hudson**, for publication this year. Both will have chapters on Caving Electronics and Rescue Communications, written by **Frank Reid**.

Back Issues: All back-issues are currently available. The price is \$1 per issue US/Canada, \$1.50 overseas. Supplies of offset-printed issues 1, 2 and 3 are nearing depletion; we may have to raise the price for Xerox copies. Perhaps we'll publish a "Best of Speleonics" anthology in the future.

Cumulative index available. We maintain a cumulative index of articles published in **SPELEONICS**. We send the index to each new member. Copies are available for SASE, from Joe Giddens or Frank Reid.

Coming next issue: We have a backlog of VLF info including **more cave radio plans**, and experiments with E-field radiators below 10 kHz.

THANKS!

Special thanks to **Don Lancaster** for nice reviews of **SPELEONICS**, and promotion of cave radio, in his monthly "Hardware Hacker" column in **Modern Electronics Magazine** (September, 1986, p. 71 and October, p. 69). Approximately 30 new members have joined as a result, and subscriptions continue to arrive. There were a few inquiries from people who didn't realize that we deal with underground radio in the literal sense, who wanted info on spy stuff, satellite descrambling, etc!

National Speleological Society and "Bats Need Friends" brochures have been sent to our new members who are not NSS-affiliated.

COVER

An engraving by Edouard Riou from the 1867 French edition of Jules Verne's **Journey to the Center of the Earth**. This illustrated edition was the second edition of the novel published. Subsequent English editions have lost the engravings' original resolution, and have obliterated the artist's name. Our cover illustration, reproduced here from a volume owned by **Angelo George**, shows explorers using an electric Ruhmkorff lamp; see the article in this issue.

LETTERS

Dear J. Giddens,

I read with great interest your advertizement in our BCRA Bulletin for your world-wide Newsletter on Cave Communications.

As you may be aware, I have long been interested in this subject, and have written a number of articles on the principles of Magnetic Induction Communication and Location System Theory and Design in the British Caving press.

I include a Xerox copy of the most comprehensive of these with this letter, for your interest.

I would very much like to subscribe to your Newsletter, and possibly contribute to future issues, since I am convinced that the development of an International Standard, in terms of Frequency and Modulation Method will, if adequately publicized and adopted, lead to a breakthrough in Communication Methodology.

This, in turn, will find its place in Expedition and Rescue technology, as well as enabling the keen, active and technologically aware Caving Club, Speleo Group or Grotto to push their discoveries to the limit, and at the same time give them an accurate estimation of the extent of any newly discovered passages.

Yours sincerely,

Dick Glover 258, CROSS FLATTS GROVE,
BEESTON,
LEEDS LS11 7BS
ENGLAND

Dear Joe,

Please put me back on the list and continue my subscription... I will be doing some cave radio work this fall and am constructing now. I will try a simple downlink using a large loop and a very low-power AM just below the edge of the regular BC band. In that way, a cheap radio can be used in the cave. I am basically lazy. Uplink is usual pulse/cw 3495.65 Hz.

Sincerely,

Brian Pease 567 Fire St.
Oakdale, CT 06370

Dear Joe,

If we have expertise in the section on making videos, should we consider making some short videos on cave radios, cave communication, to be available through the NSS or the section to interested people?

Perhaps we could use some of the \$200 [grant from the Alberta Speleological Society] to "develop the tech library." I don't think that would stretch things too much!

Ian Drummond

5619 Dalwood Way NW
Calgary, Alberta T3A 1S6
CANADA

[Great idea! Hopefully, we can get video segments from several people, showing the variations in equipment and procedure. I thought that a video camera might interfere with my audio-frequency cave radio, but in a recent test there were no problems.] --FR

Dear Joe,

Thank you for the issues of Speleonics. I enjoy reading them and thus enclose payment for a few more.

The Michie Phone system [reprinted in SPELEONICS 4] is proving to be very reliable and convenient to use. One problem we do seem to have with them occurs during those occasions when the user and cave passage are dry. The solution is simply for the user to place their other hand on the ground to provide the earth path. Unfortunately these conditions are not common and thus cavers tend to forget the need and the principle of operation.

When there is little moisture around their performance is very good. They will even operate (rx) when placed in the pocket of a caver with damp clothing, providing semi-mobile operation.

We are developing a VOX unit to connect the Michie Phone to hand held UHF/VHF radios for true portable operation both above and below ground.

Keep up the good work with SPELEONICS.

Kindest regards,

Barry Were
ZL1BNP

5 Hazelwood Ave
HAMILTON
NEW ZEALAND



The next phase of the project is to complete the interface to the telephone (phone patch). Although patch operation is not legal in NZ we feel that it can be justified for emergency use...

We have recently held our second annual Search and Rescue Communications training weekend for cavers. This involved two days of lectures, discussion and practical experience with Michie Phones and the Link plus the HF, VHF and UHF radios likely to be encountered on a rescue. We had 27 cavers involved and as a result expect considerably less apprehension by cavers faced with a communications role during a rescue.

A couple of months ago we had a major rescue - 6 cavers trapped by flood waters. It happened on a Saturday night after I had spent Friday night and all day Saturday finishing the Link. Ironically, I led the underground rescue party and had to communicate with the above-ground Search Headquarters via a relay operator because the radio conditions plus hills, etc rendered VHF signals inadequate for Link operation. No system can be perfect.

We are all into Taiwanese IBM PC Compatibles over here... We are also very envious of the prices you people are able to pay for this type of machine and accessories, i.e., disks at US\$49c compared to the cheapest equivalent here - US\$1.60.

We are contemplating the manufacturing of a run of Michie Phone handpieces, or at least the bulk of it, being the PC board and wiring to the switches. If anyone is interested we could produce a few extra with little additional effort. This is not likely to occur before March or April next year.

Perhaps we could even be paid in floppies or something.

Barry Were

[Contact Barry directly if you want one! --]

86-09-25

I really appreciate to have been on your list of "potentially interested people." ...During the meeting of the Technical and Material Commission at the UIS-congress in Barcelona we decided to use Speleonics as a worldwide forum for information about caving electronics...

In the near future I will send a paper on my DSB cave communication device...to be published in Speleonics... I am a ham since 1961 and my interest in hamradio is constructing and building of equipment. I am also very active in "fox hunting" [hidden-transmitter hunting]. My call is SM5CJW. As a caver in Sweden I have built the different communication devices we use in cave diving.

Just a few days ago we managed to dive four new sumps in one of our biggest caves in Sweden, **Lummelundagrottan**, which is now 3210 m long. Now it is possible to dive a roundtrip in the cave through 8-9 sumps!! The potential of the cave is at least 5-6 km... In order to make our diving more safe we also need more electronic equipment.

73,

Bo Lenander

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SWEDEN

NUCLEAR FLASHLIGHTS!

Terri Fermi

Perhaps the ultimate long-duration cave light is the British-made "Betelight Torch," a tritium lamp with light-emitting area 22 mm (13/16") in diameter, in a durable rubber housing with lens cap, attachment ring and neck lanyard. The thick tritium-gas-filled glass tube contains phosphor which emits soft yellow-green light, a color to which human eyes are especially sensitive. After one 12.26-year half-life, the light is half as bright as when new.

The Betelight Torch, also known as "ranger eye," is intended for commando operations. I bought one from the U.S. Cavalry Store, a military-surplus dealer in Radcliff, Kentucky (near Fort Knox), for \$30, reduced from \$70. The device is marked "SAUNDERS-ROE DEV Ltd HAYES MIDDX UK NATO No. X4/6260-99-965-3582."

Its age is unknown; the light intensity is roughly equivalent to that of the lightbulb inside an electronic wristwatch. It's adequate for reading maps if the eyes are fully dark-adapted, and is especially nice for cave-survey compass illumination. Exiting a cave with only a Betelight Torch would be difficult but possible.

Tritium emits low-energy (18.61 KeV) beta particles which cannot penetrate glass. Less than one percent of the beta particles convert their energy to soft X-rays as they are absorbed, by the

bremmstrahlung effect. **Kevin Komisarck**, physicist at the Indiana University Cyclotron Facility, measured 40 counts per second of 12-KeV X-rays coming from my Betelight Torch. The detector completely surrounded the device under test.

Tritium is dangerous if ingested. The Betelight Torch is estimated to contain a harmless quantity, however, one shouldn't break the tube, allow children to play with it, or carry it in the pants pocket.

Several years ago, Texas Instruments Co. sold LCD digital watches with tritium background-illuminators. These are no longer manufactured, following a scandal about TI's alleged mismanagement of the radioactive substance. You may be able to disassemble a junked watch (carefully, outdoors) and recover the flat glass tritium capsule, which would make a nice compass illuminator. (Suunto and some other brands of compasses are available with internal tritium lights.)

Tritium (^3H) is made by bombarding lithium with neutrons in a nuclear reactor. It's quite expensive. The government understandably restricts its distribution. Edmund Scientific Co. once advertised rice-grain-sized "betalights" for about \$10 each. A limited number could be sold to one person, and some paperwork was required.

FLASHLIGHT MAINTENANCE

Frank Reid

A cardinal rule of caving is that each caver must carry three independent sources of light, typically, a carbide or electric head-lamp, a flashlight, and a candle. Many "backup" flashlights are unreliable even for changing carbide.

The major cause of flashlight failure is bad electrical contact. TWO MINUTES' PREVENTIVE MAINTENANCE monthly or before a cave trip greatly improves the reliability of any flashlight:

1. **Clean both ends of all cells.** An ink eraser works best, or you can use rough paper, the rough inside of a leather belt, or a pants-leg.
2. Similarly, **clean the spring in the base of the flashlight.** Remove any rust or corrosion with sandpaper or a knife blade. If the spring has become weak, stretch it slightly. If the spring is unreachable because of the construction of the flashlight, retire the light from cave service and get one with a removable base.
3. **Clean other electrical contacts,** including the flat spring that touches the back of the reflector. If necessary, bend the spring inward to increase tension. Some flashlights use this spring as part of the switch mechanism; if a spring used as a switch is bent too far inward, the light cannot be turned off.
4. **Remove and inspect the bulb:** The bottom tip is made of soft solder which gets flattened by contact pressure. A flattened tip may make poor contact. The solder oxidizes rapidly, becoming dark gray and a poor conductor. If the tip is flat and dark instead of round and shiny, replace the bulb or use a small soldering iron to re-form the tip. In the field, remove oxidation by rubbing the bulb tip on a rough surface.

In some flashlights, the battery's positive terminal contacts the bulb tip directly. Constant hammering by the batteries will flatten the tip, and can break the insulation in the base of the bulb if the flashlight is dropped. If the insulation around the tip of the bulb base is broken, replace the bulb or try to repair the damage with glue if new bulbs are unavailable.

If the flange around the top of the metal bulb-base is bent, straighten it with small pliers, or replace the bulb. (Screw-base bulbs have no flange.) If the glass part of the bulb is loose from its metal base, replace the bulb or glue it back together. Silicone glue ("RTV") is best for bulb repair because it sticks to glass and withstands high temperatures.

A quick on-off test is NOT sufficient; essentially-dead batteries will give a few seconds of bright light after a period of inactivity. If the light stays bright for one minute, assume it's good. If the flashlight dims within a minute, flickers when shaken, or must be shaken to make it stay on, "field strip" it as described above before replacing the batteries.

Flashlight components are made of inexpensive metals, and depend upon spring tension to maintain connection. Dissimilar metals + moisture +

electric current = instant corrosion! Condensed moisture can cause almost-invisible films of corrosion inside flashlights, including the best waterproof units. Heavy-duty "professional" flashlights require the same preventive maintenance as less-expensive types.

If water gets inside a flashlight, remove the batteries immediately to prevent discharge and corrosion. Completely disassemble the light as soon as practicable, wash everything with clean water, and dry in a warm place. Before reassembly, clean all contacts as described above.

Flashlight switches can be destroyed by dirt and water. Switches can seldom be repaired. They should not be oiled. In an emergency, use a piece of wire or foil to make a short-circuit across the switch, and partially disassemble the flashlight to turn it off.

A typical flashlight with a type "PR-2" bulb and two fresh carbon-zinc (Leclanche) D-cells is good for only about 2 hours of light. It is designed for maximum brightness but intermittent duty--the bulb takes so much current that the cells can't supply it continuously. Alkaline cells are best for high current. Replacing the PR-2 bulb with a PR-6 will more than double battery life, at some sacrifice of brightness. Avoid continuous duty when possible; batteries last longer when allowed to rest a few minutes between uses.

My favorite flashlight is the 2-cell military-surplus "elbow" flashlight (beware of the "Official Boy Scout" lookalike). The Army flashlight is inexpensive, durable, waterproof, and has compartments in the base containing spare bulb, colored filters (for that commercial-cave effect!) and diffusing lens. There's also a thick white plastic filter which attenuates the light to almost nothing, presumably for combat use. The light comes with a pair of low-current, long-life PR-6 bulbs; uninformed cavers have complained that "Army flashlights aren't bright enough." The PR-6 bulb and alkaline D-cells can provide 30 hours of light. The flashlight has a spring clip on the back and a lanyard ring on the bottom. For night driving or flying, I clip the light onto the shoulder harness for hands-free operation.

Disposable flashlights are not cost-effective and are not recommended. They are built as cheaply as possible, on the false premise that the batteries will die before anything else can go wrong. I've dissected several types-- Like other flashlights, they use spring tension to maintain contact. Some of their non-leakproof carbon-zinc cells showed signs of corrosion even when "new." Disposable flashlights cannot be disassembled for repair, and are too unreliable for caving.

Alkaline cells ARE worth their extra cost; an alkaline D-cell contains 9 to 10 ampere-hours, depending on manufacturer. Cells are marked with the date of manufacture but the information is usually encoded.

Cells stored for long periods should be kept outside the flashlight. Cavers sometimes keep cells nose-to-nose inside their spare 2-cell flashlights, to prevent discharge if the switch is accidentally turned on. Remember, however, that in an emergency you need light immediately and can't afford to fumble in the dark and risk losing pieces.

THE FIREFLY LAMP

Lowell Burkhead
NSS 13068

Several dimmer-circuits for cave lights have been designed, using switching transistors to "chop up" the current to the bulb, thus eliminating the power loss of resistive dimmers. Switching regulators are highly efficient, but the lightbulbs themselves become very inefficient as filament temperature is lowered.

This circuit has a dimming function but is mainly intended to extend bulb life by maintaining constant voltage. A "strobe" mode blinks the light periodically, greatly extending the useful life of essentially-dead batteries by giving them rest periods. A flashing light is somewhat annoying but certainly better than no light at all! It could really "brighten up" a long wait for a caver trapped by high water.

Besides its emergency cave-lighting function, the device can be used for a beacon with very long battery life, similar to battery-powered road-hazard blinkers. Flashing beacons can mark vehicles, campsites, cave entrances or cave-rescue routes.

The circuit is designed for 9 volts but will operate from 6 to 12 v. Battery life with a 9-v alkaline "transistor" battery and PR-9 bulb is at least 4 hours. Other 3-volt bulbs may also be used.

Circuit Description. Switching frequency varies between 35 and 76 kHz, depending on battery condition and control setting. Regulation is accomplished by varying the duty-cycle of the current through the lamp. Measured circuit efficiency is 74% regardless of output voltage. With R7 set for maximum brightness, the bulb voltage is 3 volts.

When battery voltage decreases to 4 volts, Q1 is biased below its threshold and the bulb suddenly turns off. When that happens, switch to strobe mode. In about 30 seconds, battery voltage will recover and the bulb will begin to blink. It will continue to do so for 12 hours on the "dead" battery. Alternatively, replace the battery; by the time the new battery has been depleted, the old battery will have recovered enough to provide another hour of light in normal mode.

Q1 is an N-channel power FET rated 100 volts, 10 amps. A high-current FET was chosen for low on-resistance (0.14 ohm). IRFF130 (in TO-5 package) is the physically-smallest that can be used. IRF 530 is a less-costly equivalent in a much larger case. Driver transistors Q2 and Q3 are required to switch Q1 fast enough, by discharging its gate capacitance. If Q1 were driven directly from U1A,

it would produce heat and lower the circuit efficiency.

D1 is a 1-amp fast-switching diode which must be rated at least 12 volts. Its recovery time must be less than 50 nanoseconds. D2 is noncritical; any silicon switching-diode should work, e.g., 1N914.

L1 is THE most critical component. Its 40-microhenry inductance must not change when dc flows through it, i.e., the core must not saturate. L1 is 30 turns of #24 (0.051 cm diameter) wire on a Magnetics Inc. 55050 core (1/2-inch toroid, 125- μ permeability). The core is made of Moly-Permalloy™ "continuously gapped" material, which does not saturate. A ferrite core would need a gap to prevent saturation. An air-core inductor would work but might be too large physically.

U1 is an LM139 quad comparator with open-collector outputs. LM139 is a military-temperature-range component which the author had available; LM239 and LM339 are less-expensive equivalents.

U1B, U1C and U1D form an astable multivibrator with controls the lamp's flashing "strobe" mode. S2B selects two rates; fast strobe is 3 seconds off, slow strobe is 10 sec. off. R12, R13 and C4 determine the strobe rate. C4 charges through R12 and R13, and discharges through R14; R14 and C4 set the on-time (here about 1/2 second). The flasher circuit drives Q4, which enables drivers Q2 and Q3, and the output of U1A.

C1 is actually two 33-uf, 10-v dipped-tantalum electrolytics. C2 and C3 are 50-volt ceramics. C1 eliminates battery-current surges and consequent losses in the battery's internal resistance. C2 and C1 are paralleled because the ceramic capacitor's very low internal resistance creates a lower impedance for the high-frequency circuit.

All fixed resistors are 1/8 watt.

The circuit, including controls, was wired on a 1.75-inch (4.4 cm) square piece of "universal" printed-circuit board, and coated with Humi-Seal™ paint to repel moisture. The circuit could probably be built on a round circuit-board designed to fit inside a lamp headpiece, behind the reflector.

[Lowell Burkhead designs switching power supplies for Collins Radio division of Rockwell International in Cedar Rapids, Iowa. He also designs and builds his own brass carbide lamps. --ed]

ELECTRIC CAVING BEFORE LIGHTBULBS OR CARBIDE

Frank Reid

Jules Verne equipped his intrepid cavers with electric "Ruhmkorff" lamps in Journey to the Center of the Earth, an adventure which begins in 1863, well before Edison's 1879 lightbulb or the discovery of calcium carbide in 1895. Seeing the MGM movie in 1958 influenced my early caving career, and I've wondered ever since whether Ruhmkorff lamps really existed.

The lamps in the movie were powered by hand cranks. "Self-Generating! How long will they last, professor?" asked Pat Boone. "My guess is indefinitely; as long as they're wound up, the induction coils will give off current!" replied James Mason. The wonderful windup lamps were waterproof, but failed when salt got inside them and "corroded the induction coils." Anything's possible in a Hollywood Cave!¹

Journey to the Center of the Earth remains the greatest underground fictional adventure, though we may surmise that Jules Verne was not a caver. The book was first published in Paris in 1864, followed by a beautifully illustrated edition in 1867. The description of the lamps has changed and lost vital details in English editions (as have other aspects of the novel, especially in the movie version). The following translation by Indiana University history professor B. G. Martin is from the list of cave gear and scientific equipment on page 58 of the 1867 French edition:²

...Two Ruhmkorf apparatus which, by means of electric current, give a very portable light, sure and little encumbrance.

footnote:

The Ruhmkorf apparatus consists of a Bunsen battery which is activated by potassium bichromate and has no odor, and an induction coil which produces electricity from the battery, connected to a special lantern in which is found a serpentine glass, exhausted and containing a residue of carbon dioxide or nitrogen gas. When the apparatus operates, this gas becomes luminous, producing a continuous whitish light. The battery and coil are held in a leather bag which the adventurer carries over the shoulder. The lantern, placed outside, very sufficiently illuminates the profoundest darkness, and permits the adventurer, without fear of explosion, in the presence of extremely inflammable gasses, and is not extinguished even under the deepest water. M. Ruhmkorf is a learned and able physicist. His great discovery is the induction coil which permits production of high-voltage electricity. In 1864, he received the five-year prize of 50,000 francs which France reserves for the most ingenious application of electricity.

Verne spelled the name with one f. After a lengthy search, I found a reference to Ruhmkorff in A History of Electricity and Magnetism by Herbert W. Meyer.

"Ruhmkorff coil" is an archaic term (actually, a brand name become generic) for what Americans commonly call "Ford coils," i.e., dc-powered high-voltage transformers with vibrating interrupters, small versions of which were used for ignition in Model-T Ford cars. Ford coils are still available from Warshawsky/JC Whitney Auto Parts of Chicago, for about \$35.

Ruhmkorff coils were "Hi-tech" in Verne's time, a golden age of learning in France during which fundamental laws of electricity were discovered. Studies of electric gas-discharge phenomena were in the forefront of mid-19th-century science. A succession of breakthroughs ensued from investigations of light produced by static electricity in the vacuum above the mercury column of a barometer. This fascinating "quest for fire" is chronicled in the PBS TV series and book Connections, by James Burke. Electrical equipment also was widely used for medical quackery during this era.

Meyer writes, "H. D. Ruhmkorff of Paris began making induction coils about 1851. He was familiar with the work of...others who had already produced powerful coils... Ruhmkorff was an excellent craftsman, and made coils of great refinement and excellence, so that the term Ruhmkorff coil was synonymous with induction coil for many years. In order to overcome the difficulty of internal sparking, Ruhmkorff divided the secondary winding into sections, which were well insulated from each other and from the primary winding." (This insulating method is used in cave radio transmitting coils today!)

"Ruhmkorff...coils were probably the finest made anywhere. He engaged in their manufacture on a large scale and was therefore often considered as the inventor of the induction coil. One of his largest coils made in 1867 gave sparks of 40 centimeters, or about 16 inches."

"Theoretically, the discharge from an induction coil should be AC. Actually, however, the secondary voltage is so much higher when the circuit is broken by the interrupter than when it is closed that the secondary output is almost unidirectional."

Although Ruhmkorff did not build the first induction coil, he made them practical and available at an especially fertile time. Induction coils were instrumental to the discoveries of cathode rays by William Crookes (1860's), X-rays by W. K. Roentgen (1895), and to the work of Tesla, Hertz and other radio pioneers. They were used in spark-gap radio transmitters well into the 20th century.

Everyone loves a new source of light! French experiments with impractical forms of incandescent lamp date from 1854. Calcium carbide was discovered by Frenchman Henri Moissan in 1895, during an unsuccessful attempt to make artificial diamonds by fusing coke and limestone in an electric furnace.⁴ Carbide manufacture requires enormous quantities of electricity from the electric power industry which was promoted in large part by Edison's lightbulb.

Meyer does not mention Ruhmkorff lamps, but reports that Geissler tubes were produced in great numbers around the mid-19th century. These partially-evacuated tubes, often of convoluted shape, contained mercury or various rare gasses, and sometimes were made of glass containing fluorescent metallic salts, or had double walls filled with fluorescent liquid. Geissler tubes powered by induction coils are still among the most spectacular physics-classroom demonstrations. They also appear as props in old Flash Gordon and Frankenstein movies.

Bunsen batteries, widely used in the 19th century, had carbon and zinc electrodes and dilute sulphuric acid electrolyte. A porous cup surrounding the carbon contained chromic acid depolarizing agent.⁵

Although they have moving parts, Ruhmkorff coils aren't mechanically powered, and require batteries. A related device, the magneto, is mechanically driven. Spring-powered magnetos were within the technological capabilities of Verne's day, and would have been an attractive alternative to the expensive and primitive batteries then available. Gas-discharge lamps powered by induction coils or magnetos would probably have been inefficient light sources, but desirable for their then-unique advantages over open-flame lights.

Verne also mentions Ruhmkorff lamps used underwater and aboard the Nautilus in 20,000 Leagues Under the Sea (1870). "It's bright as day! And it isn't oil or gas!" exclaimed Peter Lorre upon boarding Captain Nemo's baroque craft in the 1954 Walt Disney movie.

19th-century gas-discharge lamps survive today as neon signs. Although Ruhmkorff lamps were eclipsed by incandescent bulbs, fluorescent technology has steadily advanced. We may say that Verne correctly predicted that electric fluorescent lights would be ubiquitous in the future world except, ironically, among cavers and divers.

Despite their efficiency, fluorescent lamps have numerous disadvantages for caving. A few cavers have experimented with fluorescent cave lights, replacing vibrator induction coils with efficient electronic inverters. **Walter Jaskierny** of the Windy City Grotto built a practical fluorescent cave light with enormous battery life. Walter (a power-supply engineer at Fermilab)

learned that the efficiency of fluorescent lamps increases with the length of their tubes. He achieved high efficiency with short tubes, using a special power supply circuit for which he did not disclose details.

Acknowledgement

Special thanks to **Angelo I. George** for the use of his library and for his spelean history expertise, to **Bradford G. Martin** for academic advice and French translation, and to **James F. Quinlan** for research suggestions.

References

1. Kirby, Doug. "The Hollywood Cave" (cartoon) NSS News February 1981 p. 40.
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3. Meyer, Herbert W. A History of Electricity and Magnetism. MIT Press, 1971. p. 179.
4. Burke, James. Connections, Little, Brown & Co., 1978. p. 209.
5. Morgan, Alfred P. The Boy Electrician. New York: Lothrop, Lee & Shepherd Co., 1913, 1929, 1948.
6. Armagnat, H. The Theory, Design and Construction of Induction Coils New York: McGraw Publ. Co., 1908. (From the bibliography of ref. 3; not reviewed for this article.)

NEEDED: HELP AND INFORMATION ON RECHARGING BATTERIES UNDERGROUND

In 15 months, the next Pena Colorado expedition will be spending many days underground beyond extensive sump systems. The team will be heavy users of electricity (150 watt dive-lights, communications and perhaps underwater propulsion systems) and will need to recharge batteries at campsites deep in the cave. Proposals so far include hydroelectric generators, man-powered chargers, thermoelectric generators and fuel cells.

If you are interested in developing any of these ideas into practical caving use, or can provide any information on existing systems, please contact

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Derwood, MD 20855 USA
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MINE LAMP CHARGER

Ray Cole
NSS 12460 K4GAA

[Originally from DC Speleograph, June, 1978, this may be the most popular and widely-reprinted of all cave-electronic articles. --ed.]

The miner-style electric lamps have become popular with cavers due to their ruggedness, light output, large battery capacity, availability and cost.

Unfortunately, the same cannot be said about the commercially-made chargers. The charger described will deliver a constant voltage charge to the lamp from 110 volts AC, or DC from an automotive electrical system.

The preferred method of charging a lead-acid battery is to apply constant voltage at the battery terminals until it is fully charged. The voltage applied will determine the time required for the battery to reach full charge.

With the 14.4 ampere-hour (AH) capacity lead-acid battery used by Koehler, 5.2 volts will produce a full charge condition in about 10 hours, or less if the battery was not completely discharged.

Continuous charging at this voltage will not harm the battery but will require distilled water to be added to each cell periodically. The gassing and resulting water usage caused by the overcharging can be reduced by lowering the charge voltage when the battery is fully charged. A low voltage that will keep the battery charged if it remains connected is called the float voltage, and for the Koehler lamps it appears to be around 4.6 volts. If the lamp will not be needed for sometime it can be fully charged at the float voltage but that may take several days. Always charge lead-acid batteries soon after use and leave them in a charged condition when storing. Remember to add distilled water to a battery only after it has been fully charged.

The circuit diagram for the mine lamp charger is shown in Figure 1, and the components and possible sources are listed in Table 1.

The DC voltage required can be supplied from a 12-volt car electrical system through a cigarette lighter adapter or other connection, or from 110 volts AC. T1 reduces the AC voltage to about 14 volts, which is rectified by D1 and D2. Electrolytic capacitor C1 produces smooth DC voltage. Be sure to observe the polarity on C1. Since the 12 volts DC is connected through diode D3, an OR arrangement results which will automatically select the power source with the greatest voltage. This voltage is then applied to a combination voltage-regulator/current limiter consisting primarily of IC1. The output voltage from IC1 is

determined by the following equations:

With S1 closed for charge:

$$V_{out} = \frac{1.2 (R2 + R3 + R4)}{R2 + \text{part of } R3}$$

With S1 open for float:

$$V_{out} = \frac{1.2 (R1 + R2 + R3 + R4)}{R1 + R2 + \text{part of } R3}$$

The part of R3 referred to in the above equations is the portion from the center contact to R2.

With S1 on, R1 is adjusted for 5.2 volts for fast charge, and with S1 off, R3 is adjusted for 4.6 volts for the float voltage.

The components will fit in a 5 x 10 x 3 inch aluminum chassis. Component placement is not critical. Since the case of IC1 is at the output potential, it must be insulated from the case and heat sink with a mica washer, using heat-conductive paste.

The type of connectors used to attach the electric lamps depend on the model of miner's lamp used. See Table 1.

More than one lamp can be charged at once but the total charging time may be increased. See Figure 3 for connecting the optional ammeter and connectors. The initial charge current will be about 1.5 to 2.5 amps on charge, and as the battery reaches full charge, this current will drop below 100 milliamps, depending on the battery condition.

Update and comments from Ray Cole, May, 1986:

"I use the LM317 for all of my chargers, both for the Ni-Cad variety as well as the constant-voltage chargers for the miners' lamps. They have all worked well and given good service. A lot of cavers have told me that they have had good results with those circuits. The only addition I would make to those circuits would be to use the LM350 where a higher current (3 amp vs. 2 amp) is desired. This could help when charging multiple lamps in parallel. The mine-lamp connector specified may no longer be the numbers used by Koehler... I've had requests for more efficient chargers... It should be simple enough with some of the switching regulators available now. For those who don't need the efficiency, I would recommend the non-switched chargers.

Table 1. Parts for Mine Lamp Charger

| Part | Description | Source |
|--------|----------------------------------|-------------------|
| D1-D3 | 3-amp silicon diode | Radio Shack |
| IC1 | LM317K Integrated Circuit | Radio Shack |
| R1, R3 | 100 ohm potentiometer | |
| T1 | Transformer 20-30v center-tapped | |
| M1 | 0-2 amp meter | Koehler # 1556-12 |

Heat sink for TO-3 transistor case, with mica washer and heat-conductive paste. Radio Shack
Connector: for Koehler model 5100 you will need the following part nos: 1561-8, 1561-10, FS 508, 608, 504, 508-44.

For Koehler Model 5200 Mark V, you will need these parts: Nos. 5302-4, 5309, 5314, FS 801, 505, 645, 648, 508, 803, 201-51.

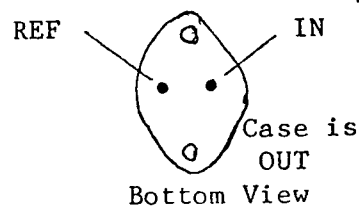


Figure 2. LM 317K Connections

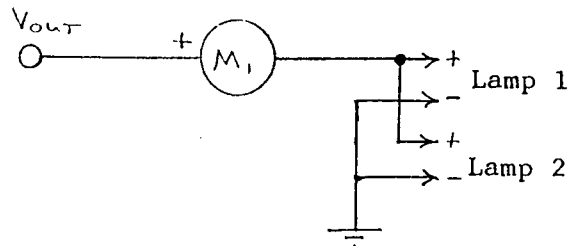


Figure 3. Connecting Multiple Lamps and ammeter

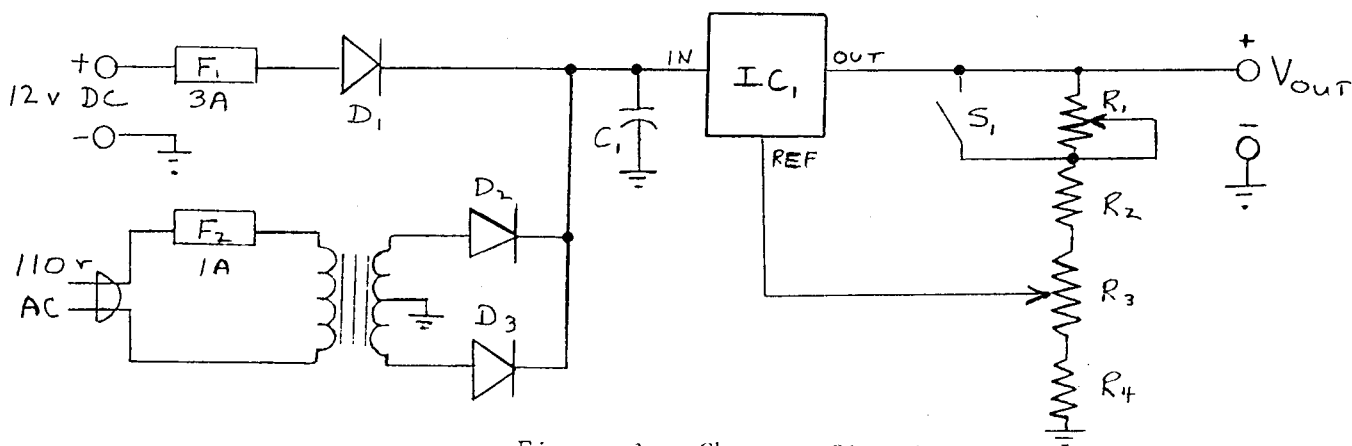


Figure 1. Charger Circuit



Cartoon reprinted from CRF Newsletter vol. 14, #2 (May 1986)

MAGNETIC MOMENTS #4: FERRITE CORE ANTENNAS

Ian Drummond

Most people are familiar with the ferrite loop antennas used in transistor radios, and with their directional properties. Can such antennas be profitably used in cave radio designs? What are the effects of putting a ferrite core in a coil of wire?

The primary effect is to increase the magnetic flux threading the coil of wire, this increasing the effective area of the coil. Since the transmitted field intensity is proportional to the area of the transmitting loop (Mag. Moments #1), and the power absorbed in reception is proportional to the the area squared (Mag. Moments #3), the use of ferrite cores at first looks very promising.

When using magnetic materials, the correct mix of ferrite must be chosen for the frequency of operation. Using a material at too high a frequency will cause high eddy-currents and inefficient operation. Using a mix below its frequency range will mean the magnetic permeability (the ability to concentrate the magnetic flux) is much lower than it could be. Materials suitable for the range from 1 kHz up to 1 MHz have bulk permeabilities in the range 500 - 5000.

Unfortunately this does not mean that the effective area of a loop can be increased by a factor of 5000 by just adding a chunk of ferrite! The problem is that a real core of finite size is demagnetized by the magnetic poles formed at the ends of the core. For materials with a bulk permeability greater than 500, the effective permeability (or flux concentration) depends only on the length/diameter ratio of the core and is shown in the graph (taken from VLF Radio Engineering by A. D. Wait, Pergamon Press)

For example, Amidon Assoc. (12033 Otsego St, North Hollywood, CA 91607 USA) sells several ferrite rods of R33 material with a bulk permeability of 800, for operation between 1 kHz and 1 MHz.

The biggest rod in their catalogue is R33-075-1200 which is 12 inches (30.5 cm) long by 0.75 inch (1.9 cm) diameter. (Calm down in the back, this is strictly an electronics catalogue!).

The L/D ratio is 16, and from the graph, the effective permeability is about 90. So the effective area of an antenna made using this rod is $90 \times 3.14 \times 0.375 = 40 \text{ in}^2$ (356 cm²). This is the same area as an air-cored loop 7 inches (18 cm) in diameter.

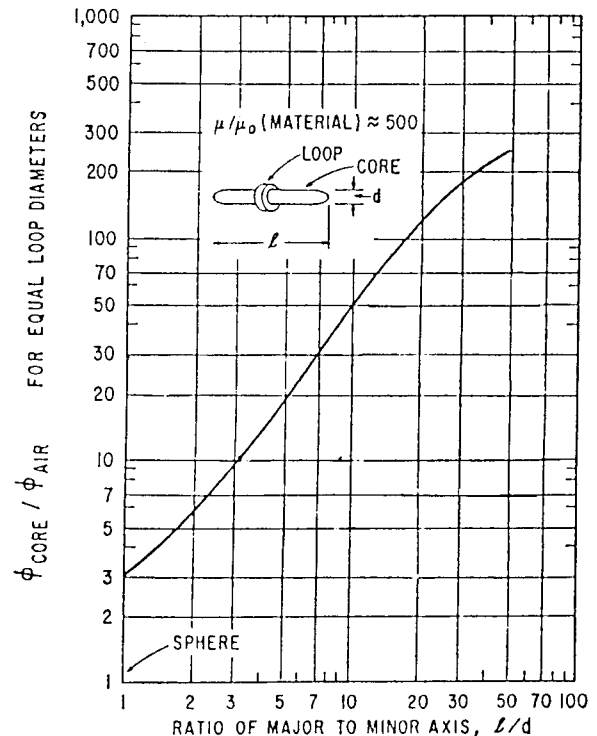
In this case, the use of the ferrite core does give an antenna that is more compact than an air-core loop of the same "size," but that size is

still very small compared to loops in common use, which range from 15 - 48 or more inches (38 - 122 cm) in diameter. This reduction in size has been obtained at the cost of weight, about 450 g (1 lb); and dollars, about US \$18.00 to purchase the core.

Thus, the use of ferrite-core antennas for transmission would only seem to give an advantage for short-range radios where small size is very important.

While the primary interest in using a ferrite core is to increase the effective area of a coil, the ferrite will also increase the inductance of the antenna. This will raise the Q and narrow the bandwidth, increase voltages and input impedances to the antenna, among other effects. These may or may not be desirable effects. If anyone is interested in designing ferrite antennas, the design program for air-cored loops published in Speleonics #2 is easily modified to accommodate them: Change line 780 $MU = 1$ to request input of MU for the core. Change line 1070 to read $NIA=N*AMPS*AREA*MU$

That's it!



Flux concentration in a short loop for a ferromagnetic core as a function of the ratio of major to minor axis.

RESOURCES

The Longwave Club of America
45 Wildflower Rd.
Levittown, Pennsylvania 19057

National association of LF, VLF and 1750-meter radio enthusiasts. Monthly publication: The Low-down. Membership: \$10 per year (\$12 after 1-87).

1750 Meters: Western Update
Jim Ericson
226 Charles St.
Sunnyvale, California 94086

Lowfer Letter
Hal Murken
19 Hobby Lane
Oakland, NJ 07436

West and East-coast newsletters of the latest happenings among 1750m and VLF experimenters. Published monthly, sometimes more often. The only acceptable form of subscription is business-size SASE's. (Donations to cover printing costs gratefully accepted).

National Speleological Society
Cave Avenue
Huntsville, Alabama 35810
(205) 852-1300

THE national network of cave explorers and related sciences, and parent organization of this publication. Monthly magazine, NSS News, quarterly scientific journal, NSS Bulletin. Dues: \$22.50/year. Numerous local chapters called "grottos." Great regional and national conventions. Information brochure on request.

COMPASS AND TAPE

A quarterly newsletter devoted to the art and science of cave mapping. US\$4.00 for 4 issues, any country, surface mail (inquire for airmail rates). Back issues available. Send check payable to NSS SURVEY AND CARTOGRAPHY SECTION to:

Lance Lide
PO Box 2601
Little Rock, AR 72203

SENSORS magazine
174 Concord St.
Peterborough, NH 03458-9990

A trade journal featuring the latest electronic sensors for everything from sewage to starlight, and application articles. FREE for answering questions on subscription form. (Title yourself Engineer and give them a company name.)

For the SERIOUS cave radio experimenter...

Take a look at this nice VLF receiver from Watkins-Johnson. It's model WJ8625-4 and it tunes 200 Hz to 1.5 MHz. We're afraid to ask the price, but if YOU are brave enough, their number is (301)948-7550 ext 528.

[Reprinted from 1750 Meters: Western Update #38.]
Picture from ad in Defense Electronics, Oct. '86.

Ben Meadows Company

3589 Broad St.
PO Box 80549
Atlanta, Georgia 30366

2601-B W. Fifth St.
PO Box 2781
Eugene, Oregon 97402

BIG free catalog of Surveying/geological/forestry/engineering/outdoor equipment. A competitor of Forestry Suppliers, individual-friendly.

Miners Inc.
PO Box 1301
Riggins, Idaho 83549

Geology and prospecting equipment, compasses, tools, books. Free catalog.

Books by Don Lancaster

Perhaps the best-known electronics author today, Don Lancaster writes books with a rare Junior Woodchucks' Guidebook quality: 100% useful information with no academic BS! His "Cookbook" series (TTL, CMOS, Active Filters, ...) are classic references among amateurs and professionals. The Incredible Secret Money Machine, about how to run your own small enterprise, is especially recommended. Lancaster books are published by Howard W. Sams, Inc. of Indianapolis, and sold at electronics stores. Don is an NSS member and member of the Communication and Electronics Section.

INTERDISCIPLINARY RESOURCES. The following reliable suppliers carry interesting items adaptable to caving:

Sporty's Pilot Shop
Clermont Co. Airport
Batavia, Ohio 45103

Free catalog, FAST delivery. Airplane accessories, survival gear, books, maps. If you had all the stuff in this catalog you couldn't get in your plane, much less get it off the ground!

Coast Navigation
1934 Lincoln Drive
Annapolis, MD 21401

Navigation instruments, Loran-C equipment, radios, sailing hardware and safety equipment. Many sailboat accessories are useful in caving; see ads for other marine-equipment suppliers in Motor Boating and Sailing magazine.

