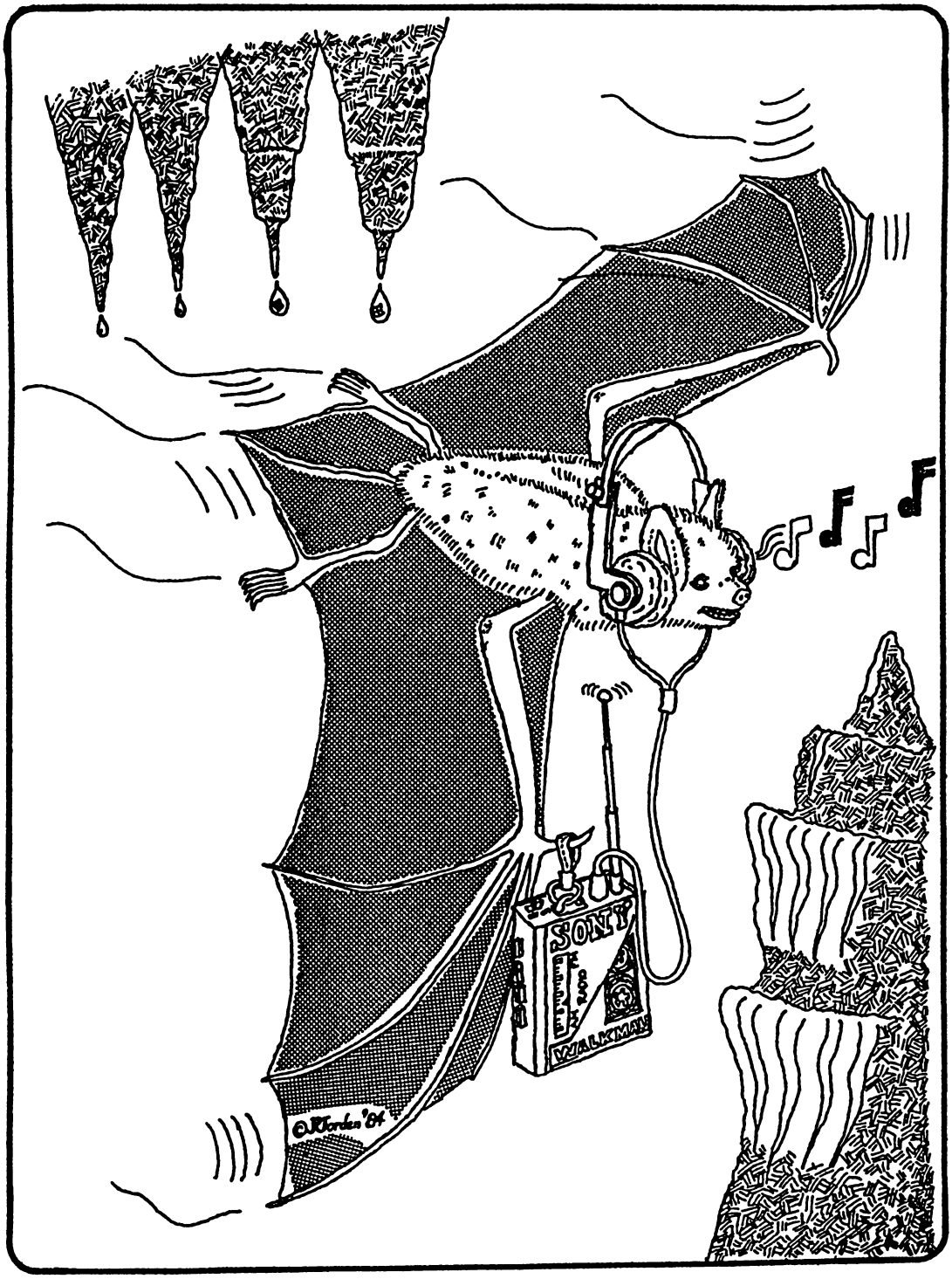
speleonics

SPRING
1985



VOLUME I

NUMBER 1

Speleonics is the newsletter of the Electronics (or Communications) Section of the National Speleological Society (the Section's name is not yet official). An organizational meeting will be held at the 1985 NSS Convention at Frankfort, Kentucky, and there will be an Electronics Session with formal and informal presentations dealing with cave radio and other cave-related electronics. Ray Cole of Virginia will present a paper on his unique cave radio design, and Ian Drummond hopes to attend and demonstrate his SSB voice cave radio. We have invited representatives of the U.S. Bureau of Mines to speak about their electromagnetic locators for trapped miners; no reply yet from USBM.

Co-editors are founding father **Joe Giddens** (PO Box 170274 Arlington, TX 76003), **Ian Drummond** (5619 Dalwood Way NW, Calgary, Alberta T3A 1S6 Alberta, Canada), and **Frank Reid** (PO Box 5283, Bloomigton, IN 47402). Present plans are for a rotating editorship, with Ian to handle articles and from outside the USA while Joe edits material from Western U.S. and Frank does Eastern U.S. material (dividing the country roughly at the Mississippi River). **Diana George** (N9DEJ) has volunteered to be our publisher, starting with the next issue. She's presently doing an outstanding job printing the Louisville Grotto's Karst Window.

Membership: Yearly dues are $4.00; Joe Giddens (address above) is acting treasurer. YOU DON'T HAVE TO BE AN NSS MEMBER TO JOIN! (How's that for nonexclusivity?) To those charter members who sent their money to Joe after seeing the notice in the NSS New of the section's formation, we must apologize for the startup delay in the newsletter; thanks for your patience!

Editorial

A disproportionately large number of cavers have working knowledge of electronics, either professionally or as a hobby, yet, NSS Convention papers dealing with electronics have traditionally received low priority, being scheduled at odd hours on the last day of convention, or being appended to various sessions as afterthoughts. We now have our own **Section** with which to "rectify" that situation!

A few purists want no "technology" associated with caving-- Such people typically disdain electric lights because carbide is more "basic." (True, in that the residue has a pH greater than seven. They seem to forget that the chemical energy in carbide comes from electricity.)

The Vietnam War has been over for a long time; technology is "in" again! Technology does not compete with humanities; technology is a humanity. Technology is the first manifestation of humanity, and underlies all the other humanities. Technology and humanity began together when apes started making tools and using fire, thus becoming **Cave Men!** We respect the opinions of those who go caving for spiritual or philosophical reasons, and desire the same consideration.

Relevant theoretical papers are welcome. Publication priority goes to useful, working electric and electronic devices for caving, with emphasis on construction details, e.g., cave radios, hydrological/meteorological/biological instrumentation and telemetry, ultrasonic devices for bat study, mapping aids, lights and battery-charging systems, cave-rescue communications, electronics packaging for the cave environment. We'll also publish unique nonelectric devices, e.g., optical systems for surveying.

There already exists an NSS Computer Applications Section, which is primarily software-oriented. Therefore, our dealings with computers will emphasize their hardware aspects, e.g., interfacing to experiments. The NSS Cave Lighting Section is concerned primarily with carbide lamps.

BETTER CAVING
THROUGH ELECTRICAL STUFF

ground communications, we highly recommend the **Longwave Club of America**, 45 Wildflower Rd., Levittown, PA 19057. Membership is $10 per year, for which you receive a monthly publication, The Lowdown. It contains excellent articles on LF and VLF transmitting and receiving equipment and antennas, including lots of information about the 160-180 kHz license-free band, and even an occasional article about operations below 10 kHz. The LWCA has published some excellent anthologies.

Section projects, not necessarily in order of importance:

1. A quarterly publication.
2. Our own session at the NSS Convention.
3. Compiling a bibliography of electronic publications related or applicable to caving.
4. Working with the National Cave Rescue Commission to (a) compile a list of cavers with amateur radio licenses, who are willing to provide communications services during rescues, (b) compile a list of whereabouts of working cave radios available for rescue purposes, (c) develop new techniques and equipment for cave-rescue communication.
5. Designing high-performance, easily-reproducible cave radios.
6. Updating NSS Caving Information Series publications on cave radio.
7. Reprinting good electrical stuff from grotto newsletters, which is often obsolete by the time it appears in **Speleo Digest**. NSS cave-files chairman Dick Blenz has agreed to glean such articles from the newsletters he receives.

Word Processing

The main idea is, SEND STUFF IN! Plain old typewriters and legible handwriting are fine. I'm using WordStar software on an IBM PC to write this. I can take WordStar files written on other systems, e.g., CP/M, and I may be able to translate other word-processing formats, using a program called "Xenocopy." (Don't forget to send hard-copy.) Let us know what kind of word processor you use, and we'll try to accommodate.

Calling all Cave Radios

How many working cave radios are out there? Please write and tell us about yours. With your explicit permission, we'll pass the information along to the National Cave Rescue Commission, and you might get a free ride in a C-130 someday!

There are two philosophies of cave-radio design: (a) The "democratic" approach-- limited range but easy to build with common parts, and (b) the "military" approach-- high performance but requiring esoteric parts, complex alignment procedures, etc. people don't want to build inferior equipment but lack the resources for more sophisticated projects. As technology progresses, it becomes easier to build complex devices. (Radio Shack sells some very high-tech parts these days.) We believe that the time has come for "The People's Cave Radio," which is both high-performance and easily-reproducible. We have extensive references, including details of a small Wheat-Lamp-powered mine-rescue transceiver designed by General Instrument Corp. We should be able to adapt and combine that and other designs for cave use. We solicit your help and suggestions. In the future, the Section may be able to purchase critical components in quantity, and supply circuit boards or kits.

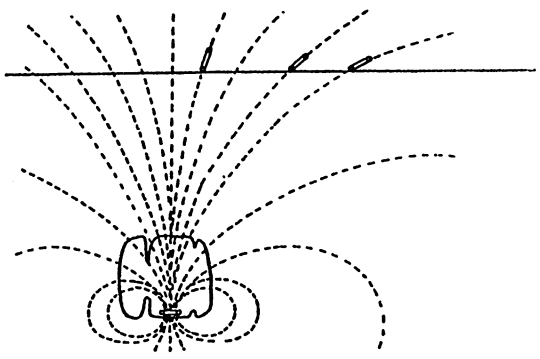
Some planned future articles:

Coil-Winding Machines for Cave Radio
Safe Tester for Flashbulbs and Blasting Caps
How to Make Flashbulb "Cluster Bombs"
Solar Wheat Lamp Charger
Modifying the Wheat Lamp Charger for Mobile Operation
Surplus M57 Firing Device: A Blasting Machine for Cavers
Universal Phone Patch Links Radios, Field Telephones and Ma Bell
Loran-C for Cavers
Portable Repeater Links Radios and Field Telephones for Cave Rescue

QST! QST! QST!

All cavers with amateur radio licenses please write! There are a lot of you out there! We'd like to hear about any cave-related applications of ham radio. Maybe we can organize things like a variable-frequency portable repeater for rescues and NSS Conventions. If you're willing to provide communications services during cave rescues, please so indicate; ham radio has proven invaluable to cave rescue, and is especially effective if manned by caver/hams, who know both worlds. (The radio operator has the easiest job at a cave rescue; it sure beats dragging bodies out of caves! At least two Indiana cavers became hams as a direct consequence of the drownings in Salamander Cave in 1975.)

F.R.



MAGNETIC MOMENTS

by Ian Drummond

This article is the first of several on the general topic of magnetic coupling between underground and surface loop antennas. I hope they will give practical information to people building radios, to allow them to make use of information from other devices, and to provide indications on how to design radios for special applications.

If I had had access to this information when Julian Coward and I started our units, we could have saved hours, dollars and got more range! All articles will have examples from my own experience.

The articles will be about the general setup shown in Fig. 1. Some of the topics I hope to cover will include:

Effects of conductive earth
- * Attenuation of signal
- * False nulls, limits to position location methods

Antenna design
- * Air-core loops for transmission
- * Air-core loops for receiving
- * Ferrite-core loops

Noise
- * Noise spectra
- * Limits to range of cave radios
- * Coherent continuous-wave radios

In this first article I want to deal with the problem of attenuation of the magnetic field by a conductive earth between the transmitting and receiving loops.

For example, consider this problem. I have a radio operating at 115.4 kHz and 10 w power. It drives a 0.71 m square loop and I can hear speech 200 m away under optimum conditions (low noise and dry alpine terrain). I want to make a small "walkie-talkie" to give speech to 50m, but with the antenna small enough to keep in my side-pack so that I don't have to stop and set it up each time I want to use it. Is this possible?

To solve the problem I can calculate the magnetic field produced 200 m from my existing antenna and then calculate the size and current needed to give the same field 50m away.

Before calculating the field I want to introduce the idea of Skin-Depth, which is a distance characterized by the frequency of the magnetic field, by the conductivity of the medium, and by its magnetic susceptibility. For limestone (and most other rocks) the susceptibility is equal to that of free space ($4\pi \times 10^{-7}$ Henries/m) so the skin depth depends only on the frequency and conductivity. The formula is

$$\text{Skin-depth (metres)} = 1/\sqrt{\pi f \mu \sigma}$$

where: f = frequency
$\mu = 4\pi \times 10^{-7}$ H/m
σ = conductivity (mho/m).

The value of the skin-depth can be calculated or looked-up in fig. 2. For example, dry limestone terrain has a low conductivity of about 0.001 mho/m so at 115.4 kHz, the skin-depth is about 50 m.

The magnetic field can now be calculated on the axis of the 0.71 m loop, 200 m away, using the following formula:

$$H \text{ (magnetic field, A/m)} = \frac{n I A G}{2\pi d^3}$$

where: n = number of turns, I = current (amps), A = area of loop (m^2), d = distance (m) and G = tabulated factor (fig. 3).

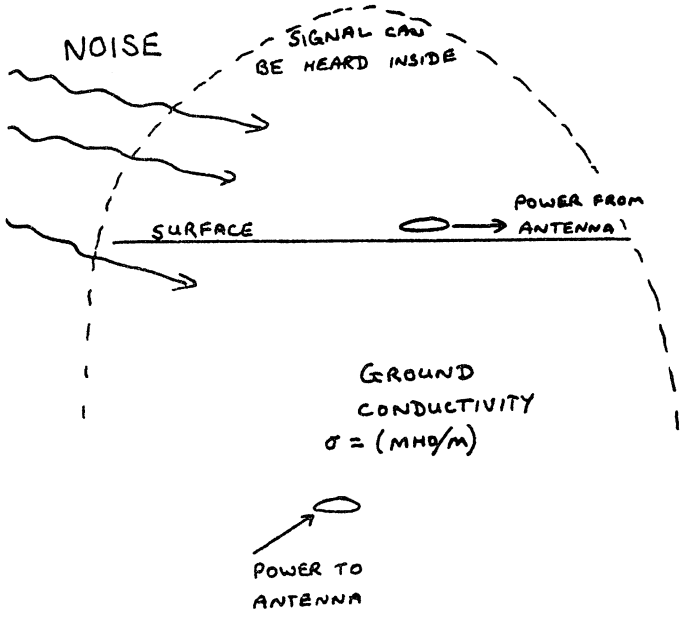


Fig. 1

For my loop n = 70, I = 0.32 amps, A = 0.50 m^2, d = 200m, and from fig. 3 at 200/50 = 4 skin depths, G = 0.15,
so H = 3×10^{-8} A/m

Suppose for my "walkie-talkie" I wind 100 turns on a 3 1/2" diameter plastic pipe (area = 0.0062 m^2). I want to know what current I would need to give me a field of 3×10^{-8} A/m at a distance of 50m or 1 skin depth, (G = 0.84) So 3×10^{-8} = (100 x I x 0.0062 x 0.84)/($2\pi \times 50^3$)

So I = 0.04 amps.

This is a small current, easily produced in such a loop, so the idea of the small walkie-talkie is not unreasonable. The smaller loop will absorb less power from the magnetic field at the receiver which may need more gain. I will cover that aspect in a later article.

Next time I will discuss how to design an air-core loop to give a known N, I, A,; how much power it can handle.

References Fig. 3 is from "Performance of manpack EM location equipment in trapped-miner location tests" by A. J. Farstad, in NTIS PB231154 "Thru-the-earth electromagnetics workshop" (1973). The diagram is based on the work of J.R. Wait, for example, Proc. IEEE, June 1971 p. 1033-1035.

Skin-depth	G
0	1.00
1	0.84
2	0.55
3	0.30
4	0.15
5	0.068
6	0.032
7	0.0103
8	0.0054
9	0.0027
10	0.0010

Figure 3

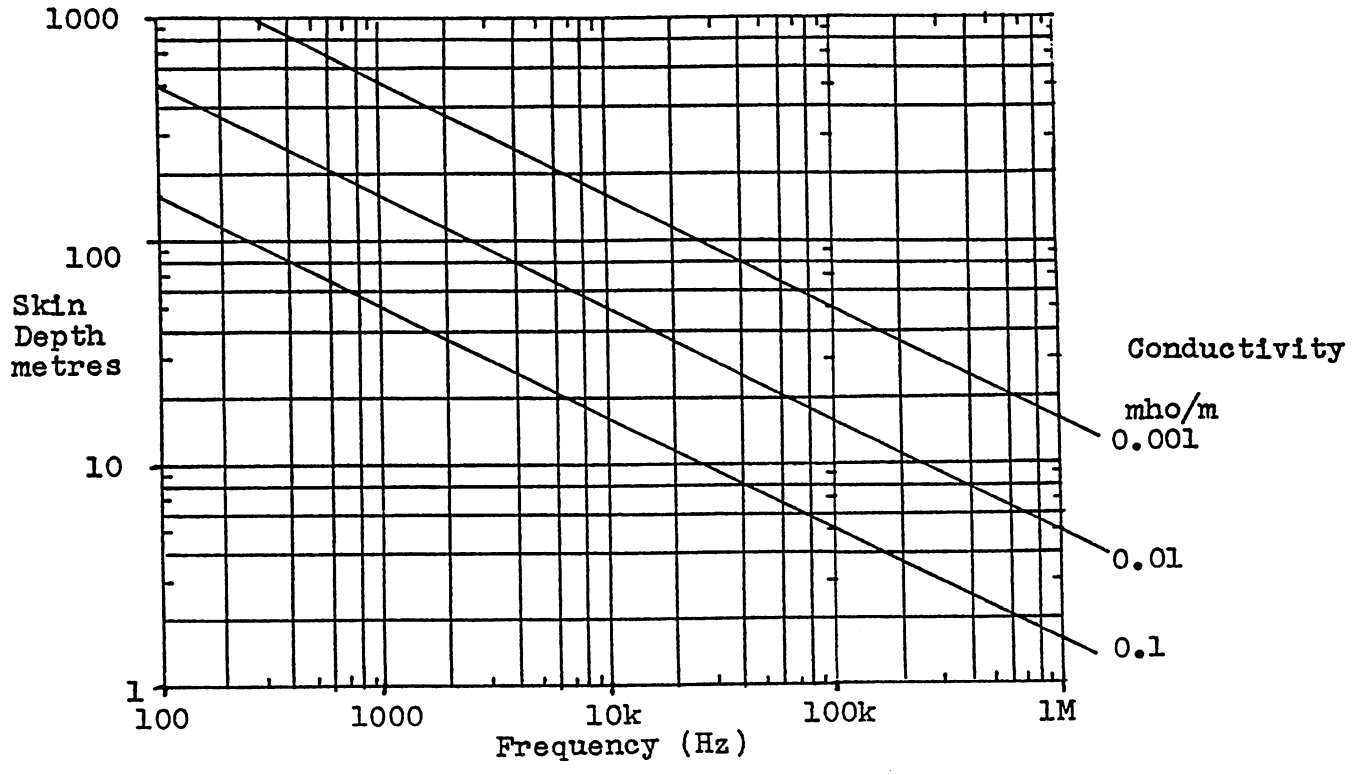


Figure 2

Reprint:

RADIOCOMMUNICATIONS IN APE CAVE, WASH

Washington Speleological Survey
Bulletin #16

January 1981

(Western Speleological Survey Serial #64)

William R. Halliday

Introduction

One of the present requirement for use of St Helens Review Committee research permits in the Mount St. Helens Red Zone Closure Area is constant radiocommunication with an amateur-band base station. Recently an administrator of the Gifford Pinchot National Forest reiterated earlier statements by a former administrator that radiocommunications are not possible underground. referring to Ape Cave and other Mount St. Helens caves, a local newspaper recently reported (Gantenbein, 1981):

> "Osmond said that radiocommunications are impossible inside the cave. He said a spelunker inside the cave during an eruption would be unaware of the danger."

Especially in view of other anti-speleologist statements made earlier by the other administrator of the Gifford Pinchot National Forest (Halliday, 1980), recurrence of this assertion was interpreted as a scarcely-veiled step toward revocation of SHCC Permit #10 for current speleological research in the Caves Basalt Lava Flow area, and/or rejection of applications for subsequent speleological research permits. Urgent action was considered essential.

Field Work

On January 3, 1981 five speleologists from the Oregon an Cascade Grottos of the National Speleological Society and three members of the Clark County (Washington) Amateur Radio Club sought to use SHCC permit #10 for appropriate studies in Ape Cave and other caves of the Cave Basalt Lava Flow, including a test demonstration of radiocommunications in Ape Cave. The Red Zone had been closed, but everyone was aware that a U.S. Geological Survey party was to be allowed to enter the crater that day, so we assumed that the closure had been lifted or was about to be lifted. As published in the Speleograph (Taylor, 1981):

"After a long period of waiting in the lot of the St. Helens Ranger station on this cold, perfectly clear day without discernible seismic activity, we were informed by Forest Supervisor Tokarczyk that we could not enter the Red Zone....This verdict was especially disheartening because we were able to monitor by radio the USGS's preparations to go into the crater, and watch their helicopters descend upon the mountain..."

However on January 10, 1981 we were successful in using our permit. On that date, three members of the Clark County Amateur Radio Club again accompanied a Western Speleological Survey team comprised of members of the Oregon and Cascade Grottos of the National Speleological Society: Don and Helen Krehbiel (W7PLF and WB7TKZ) and Ron Campbell (WB7NAU). Base station KA7DNB was manned by Fred Reed, and radiocommunications were maintained on amateur frequencies between the vehicles and the base station at all times when in the Red Zone. Besides the official base station, the Krehbiels estimated that approximately 100 other "hams" in the Vancouver-Portland area were monitoring our operations unofficially as well as the operations of others in the Red Zone.

At Ape Cave, the vehicles were parked facing south on Road N604 alongside the parking lot, in the configuration required by the Gifford Pinchot National Forest administrators. In the cave, a Tempo S-1 handheld unit with a telescoping 1/4-wave antenna was used on a 2-meter frequency.

This set permitted excellent voice radiocommunications between the speleologists in the cave and the vehicles, at the farthest points permitted by the "15-minute limit" on travel away from an "escape vehicle." The down-tube point was the lower end of the main passage (more than 1.2 km from the main entrance); up-tube it was the first lavafall (about 0.8 km from this entrance). During the down-tube traverse, three or four zones of signal loss were noted but each was found to be no more than five to ten paces in length.

Also it was noted that on a randomly selected AM portable radio about 20 years old, some Portland AM radio stations were received clearly in Ape Cave.

On the following day, the same Tempo S-1 unit was used uneventfully for similar radiocommunications between the vehicles and the interiors of other caves as much as 1 km from the cars.

Historical Background

Use of radiocommunications in caves dates at least to 1930, when AM reception and some shortwave communications were demonstrated in Endless Caverns, Va., Carlsbad Cavern, New Mexico, and elsewhere (Nicholson, 1930; Taylor, 1981, Halliday, 1976). About 20 years ago, radiolocation and mapping were producing some dramatic results (Halliday, 1976). Around 1965, Robert Brown, Jerome

Frahm and I used 4 or 5-watt CB handheld units in and around Ape Cave, obtaining radiocommunications much like those obtained on the amateur bands on 1-10-81. One June 22, 1980 Dale Justice of the Portland-based Tektronix Employees Amateur Radio Club (K7WWR) used an automatic relay unit for providing amateur band radiocommunications for a Western Speleological Survey team which went as far as the Meatball without incident. On August 23 and 24, 1980, Tom and Jeff Luther of the same club (K7HFW and WB7TBE) used a somewhat similar relay rig with another party in the cave, but equipment problems limited its spelean range to about 0.7 km beyond the main entrance.

Conclusions

Now it should be clear that radiocommunications are possible in caves, and Western Speleological Survey parties are complying with present regulations requiring amateur-band radiocommunications at all times while in the Red Zone.

Acknowledgements

Without the generous assistance of Don and Helen Krehbiel and Ron Campbell, and of Fred Reed and Oran Ewing who manned the base stations on January 10 and 11, 1981, our studies would not haves been possible. My sincere thanks also to Fred Dickey, Don Denbo, Clara and Roger Lamarche, and Becky Taylor who provided the field assistance on January 10, 1981.

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Gantenbein, D. 1980. Mountain that made caves might destroy them. Vancouver (Wash.) Columbian, Dec. 14. Quoted in: Speleograph, Vol. 17, #1, pp. 5-7, Jan.

Halliday, William R. 1976. Depths of the Earth; revised and enlarged edition. New York, Harper and Row, pp. 123, 125, 167, 177-178.

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Taylor, R. 1981. A postscript from the editor (includes reproduction of 1930 postcard of radio reception in Endless Caverns, Va. from Roger Silver collection). Speleograph, Vol. 17, no. 1, Jan., p. 8.

EMERGENCY LIGHTBULB REPAIR

Frank Reid
Dwight Hazen

No April Fool or ethnic joke-- it is possible to repair a burned-out lightbulb! You can often repair the same bulb several times, and the repaired bulb is brighter than before. Don't throw old bulbs away until you reach a source of new ones.

Bulbs are a weak point of electric cave lights because the filament breaks easily if the lamp receives a hard knock while turned on. Bulbs in cave lights rarely "burn" out-- after long use, the filament becomes thinner because the tungsten slowly evaporates, forming a black deposit on the inside of the glass. The thinner filament is more fragile, and finally breaks from mechanical or thermal shock. Even new bulbs can fail if the lamp is impacted while turned on.

Many cavers operate their bulbs at higher than the rated voltage, trading reduced bulb-life for brighter light but compounding the mechanical-shock problem. The low-voltage, high current bulbs of Wheat Lamps and other miners' lights have relatively short, thick filaments which are much stronger than those of flashlight-type bulbs.

Here's a trick for getting extra light in an emergency: With bulb in lamp and switch turned on, orient the filament vertically, with the longest piece hanging down (we assume here that you have some auxiliary light source). Tap the top of the reflector assembly with your fingers, or gently bang the bottom on a hard surface. The idea is to get the filament and its supports vibrating so that the broken ends of the filament touch. When they do, they weld themselves back together and you get more light-- more, in fact, than before, because the filament is now shorter and draws more current. It's still very fragile; avoid turning the light off until you reach security. If the filament breaks again, just repeat the procedure. This method works best with low-voltage bulbs (12 volts or less). The longer filaments of higher-voltage bulbs usually break into several pieces when they fail.

How many cavers does it take to replace a lightbulb?

NONE!

Abstracts of some papers to be presented at the 1985 NSS Convention:

ORGAN CAVE SYSTEM RADIO

by Ray Cole, NSS 12460

ABSTRACT:

The cave radio described was constructed to locate underground points in the Organ Cave System in order to better control survey accuracy. Of particular interest were areas of the cave that were distant from entrances and not contained within multiple survey loops. It was desired to construct the simplest possible equipment that would be adequate to locate underground points at depths approaching 500 feet. Unfortunately earlier models did not come close to the design range. By incorporating a novel commutating filter recommended by Brian Pease it was possible to extend the range to more than 1000 feet. The filter allowed a narrow bandwidth and a second commutator re-synthesized the received signal on a different frequency for monitoring. This effectively eliminated feedback which otherwise would result from the headphones coupling to the receiving antenna. The cave radio operated at 3,495.6 Hz using crystal controlled transmit and receive frequencies which allowed a detection bandwidth of less than 15 Hz. A morse code key was used for two way communication. The underground antenna consisted of a 6 foot diamater loop that could be folded up into a small soft pack. After the underground antenna was placed on a plastic sheet, rocks, sand and gravel were used to level the antenna as measured with a string level. A 20 inch diameter surface antenna allowed measurement of surface position and depth of underground points. Each of the two cave radios constructed was assembled in a 3 by 4 by 5 inch aluminum enclosure which housed the readily available analog and digital electronic components that were used.

A TELEPHONE-TO-RADIO REPEATER FOR CAVE RESCUE

Frank Reid, NSS 9086

ABSTRACT:

A specially-modified radio repeater controller interconnects two-way radios with field telephones, automatically linking the underground and surface communications systems used in cave rescue. Telephone conversations are transmitted by radio. Received radio traffic enters the phone line and is retransmitted, thus increasing the range of portable radios. The receiver (on a frequency different from that of the transmitter) is located several hundred feet from the transmitter, to prevent overload. The controller uses a voice-operated relay, and works with a wide variety of radio equipment. The repeater provides access from the cave to an outside radio channel, saves time, preserves message integrity, frees surface communications operators for other work, and simplifies the on-site rescue coordinator's duties. Since any telephone connected to the system functions as a semi-portable radio, the repeater provides low-cost expansion of radio facilities. Preliminary tests at a rescue training exercise indicates that the repeatr system is a useful training aid, and, properly managed, can enhance communications in real rescues. Further testing is planned at the 1985 National Cave Rescue Commission seminar.

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TREASURER'S COMMENT:

The section had $88.00 in an Arlington, Texas bank before postage was bought for this issue. Printing was courtesy of Geo-Magnetics Inc. JDG

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ACKNOWLEDGEMENTS:

May circular displays of electromagnetic waves in the visible spectrum orbit the craniums of: Jay Jordan for the first cover; Frank Reid for items on pages 1,2 & 6, and the editorial; Ian Drummond for an article on pages 3 & 4; and William Halliday for material on pages 5 & 6. Frank Reid also did the printing and paste-up for this issue after my Apple incurred an expensive illness.

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LATE NEWS:

The Communications and Electronics Section will have its session on Monday, June 24, at 8am to 12am with the section lunch from 12 to 2pm. The convention schedule is reproduced on page 8 from the May NSS NEWS and the April NSS BULLETIN for your convenience. Several papers are to be given, elections held, section name decided, etc.

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MORE QST!

Frank mentioned some projects in his editorial---some dealing with a bibliography ---others with ham and cave radio lists. In addition, a want and have list is circulating amoung folk of NCRC ilk and may well carry electronics items in addition, as many of these folks have both interests. The ham list is about 15 QSL cards and growing, but the "cave radio" list is nil. In addition to the call sign, it is helpful to know frequency preferences and time, as well as equipment capability.

Suggestions for future articles as well as some articles are solicited. We could also use some humor and cartoons---if we don't get some---we will be forced to use Frank's cartoons!

Names of interested parties are solicited and if forwarded to one of the co-editors, we will send a copy of SPELEONICS. Your $4 is good for 4 issues and you are one of 22 paid up members if there is a purple dot by your name on the mailing label. JDG