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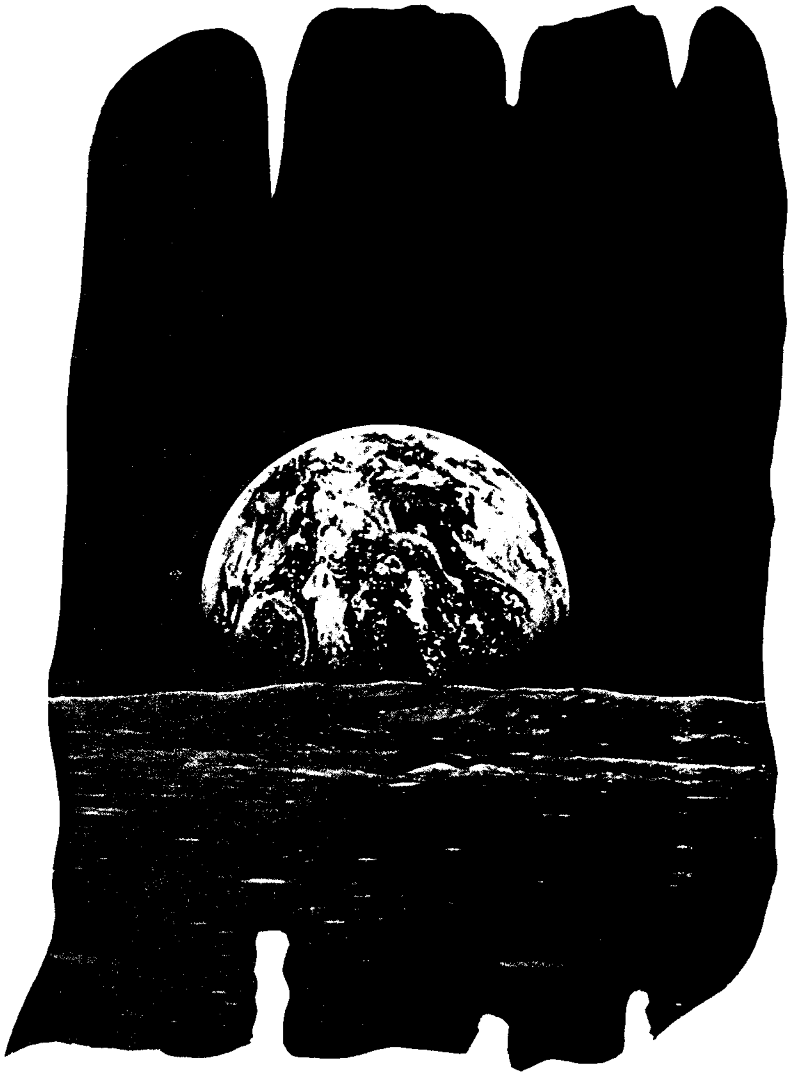

CAVERS TO THE STARS!

In this 21st year after the first manned landing on the Moon, we note that caving may be an invaluable skill when people colonize other worlds.

Resources and New Products -
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SPELEONICS 14

Volume IV, Number 2 February 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 SPELEONICSO. 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.

Chairman (and editor of this issue):	Secretary (and editor of issue #15):	Treasurer (and editor of issue #16):	Publisher:
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EDITORIAL

This edition of SPELEONICS centres around guide wire methods of communications. A guide-wire provides a system to channel electromagnetic energy from the sender to the receiver, rather than allowing the signal to be broadcast. This is not only an efficient way to use the energy (long range on little power), but allows the signal to be directed where it would not normally reach, such as into a mine, or through a tunnel.

The guide wires in common use commercially are some type of electrical conductor which may be specially designed and deliberately installed, such as the "leaky" coaxial cable systems; or they may be metallic items installed for other reasons, such as rail lines or compressed air pipes in mines. The frequencies of operation cover a wide range, from 150 MHz down to 100 kHz at least.

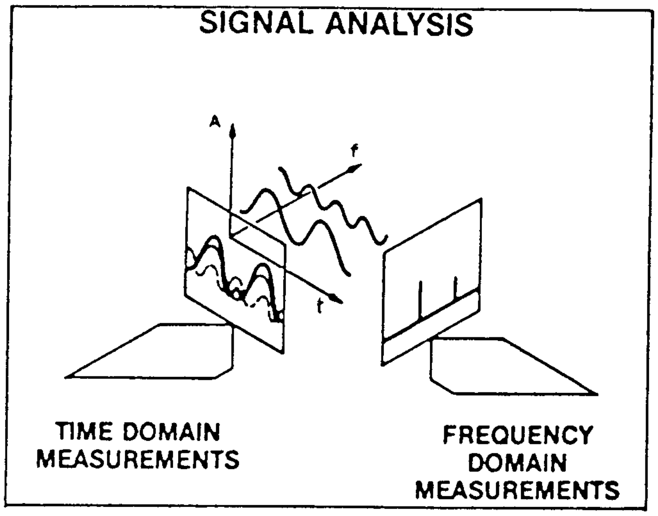
Why might cavers be interested in guide-wire systems? If a wire must be installed to provide the communication link, telephones already provide a proven and cheap means of voice communication.

The big advantage of the guide wire must be that a physical link to the wire is not needed. The radio couples inductively to the wire and anyone within 10 m or so of the wire can communicate with anyone else near the wire, anywhere along its length. It is possible to communicate while walking beside a stretcher, or hanging from a rope in a big pit, as was described by Pete Hart in his letter to Speleonics No 4, page 2, about use of CB radios with guide-wires in Epos Chasm in Greece.

Perhaps the most exciting possibility of all could be the use of guide-wire systems while swimming through a sump. The cave diver must lay a guide-line anyway, and if a conductor is part of the construction of the line, then it is possible that two-way voice communication could be maintained between a diver and his diving base, or between two divers, up to distances of several kilometers. I understand from Noel Sloan that suitable diving line already exists, but I have not been able to get detail of supply or cost from him.

While practical experiments could certainly be tried at present, a theoretical analysis of such a communications channel would be most useful. SPELEONICS did review a book "Leaky feeders and sub-surface radio communications", by P.Delogne in issue No.3, page 10, and in addition a quick check of the engineering literature turned-up a paper of interest, "Electromagnetic Wave propagation along a buried insulated wire" by J.R.Wait, Canadian J. Physics, 50, 2402 (1972). While the calculations are complex (I could not resist the pun!) some guidance could be given on suitable frequency, wire/insulation sizes, predicted range, etc. Perhaps this would form a suitable thesis topic for an electrical engineering student; the subject is wide-open. Be my guest!

--Ian Drummond



Time- and frequency-domain measurements illustrated.

From Microwave System News, January 1989 p. 26.

News and Announcements:

THIRD ANNUAL MEETING AT DAYTON

Members and friends will again meet informally at the Dayton Hamvention, Saturday 28 April at 11AM local time. This year we will try an OUTDOOR meeting, on the grass between the big rocks and the WEST side of the main arena, near the front fleamarket gate, in the vicinity of the lowest-numbered fleamarket spaces. Look for the SPELEONICS cover posted on the wall.

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FAX NOW AVAILABLE

SPELEONICS editors now have FAX capability:

Joe Giddens: (501) 574-0200 extension 462C
Frank Reid: (812) 855-8299

These are Joe's and Frank's employers' FAX machines, which are shared by many people: Please include something in messages to identify the recipient.

--

LF/VLF BBS

For those interested in longwave radio (below 550 KHz), there is now a computer bulletin board devoted to this topic. It is ...

---- The LongWave DataBase System (LWDBS) ----
PO Box 10116, Arlington, VA 22210
Phone: 703-528-7753
Speed: 300/1200/2400 baud
Schedule: 24 hrs/day, 7 days/week.
Sysop: Lynn C. Ashley, Jr.
LWDBS is PC Pursuitable via the DCWAS pathway.

Anyone with an interest in longwave radio is invited to call. This includes non-directional beacons, LowFERS, LORAN & Omega, etc. This board is for *long* wave interests only. --**Pat Harrington** jph@astro.umd.edu

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1990 NSS CONVENTION: CALL FOR PAPERS

This year's National Speleological Society annual convention will be in Yreka, California, 9-13 July. We hope that some of our West Coast LF/VLF friends can attend the Electronics Session (not yet scheduled). If you would like to present a formal paper (abstract published in NSS Bulletin), please send abstract(s) to **Frank Reid** before May 1. As usual, our session will include informal show-and-tell discussions, so bring your projects!

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AUSTRALIAN CAVE-DIVING VIDEO

We have received a copy of Nullarbor Dreaming, the 50-minute video about the international cave-diving expedition where an entrance collapse trapped 13 cavers underground. **Ron Allum**'s cave radio provided communications between cavers and rescuers (see SPELEONICS 12). Look for this highly impressive and professional video at the NSS Convention and on the "Discovery" cable-tv channel (which has broadcast several other cave-exploration programs). We have been asked not to copy the tape, which is distributed through **Karst Environmental Services**, P.O. Box 1638, High Springs, Florida 32643.

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Letter:

Dear Mr. Drummond:

Your article in Speleonics, vol. III no. 1, pp.9-10 was extremely interesting to me because I am working on a low-level detector that takes advantage of natural and man-made noise. I am using the broad-band noise signal rather than the communications information for which everyone else is listening.

Tab Books no longer has copies of your Reference 2, P.N. Saveskie's Radio Propagation Handbook...

I tried an experiment recently which bears on the underground communications problem: I inserted a square-wave audio-frequency signal into moderately wet soil with two ground rods (i.e., 16-penny nails) spaced about 20 feet apart. The power source was a commercial function generator whose square-wave signal is 2 volts AC (measured with a digital multimeter). The output impedance of the function generator is 600 ohms. I could pick up those signals easily up to forty feet away with my prototype voltage detector, using a pair of electrodes spaced about 18 inches apart, and feeding into a 741 op amp connected as a difference amplifier with a voltage gain of 60dB, thence to an audio power amplifier and earphones. The frequency did not matter much between a few hundred Hertz up to the highest I can hear, about 10 kHz. My detector's input sensitivity is about one microvolt (two microvolts per meter for the dipole electrode array) in that frequency range. I do not pick up anything with the electrodes off the ground because the leads and my detector are shielded. Of course I also pick up a 60Hz signal from the ground. **When I inserted a 64Hz signal, I could hear the beats between it and the 60Hz interference easily.** [emphasis added --ed]
onics 8, vol. II, no.4, pp.6-8 (April 1989), Phil Ingham says that the voltage varies as 1/ distance around an electrode inserting a current into the ground, not only laterally, but also with depth into the ground. Perhaps the skin effect is not the kiss of depth for electronic cave communications after all. One over distance for the voltage probe is a lot stronger than 1/(distance)^3 for the magnetic radio.

What's needed is for the voltage detector to use a dipole probe connected directly with the ground; if there is enough input impedance in the detector circuit, then the electrode connections do not have to be terribly good.

Note that you might want to combine both methods, since the magnetic radio is much more directional than the voltage probe. My voltage detector is polarized only quite near strong sources; farther away, such as half a mile from the nearest power line, it is not directional at all.

Thank you for communicating your ideas so freely to the caving community... Amateur communications like this newsletter make many professional journals look pretty weak and slow, because your working group acts as a peer review committee in the whole. I've learned more about radio propagation and detection from Speleonics than from all my college courses combined.

Thank goodness for a free country.

Yours very truly,

George Langford, Sc.D
Principal Consultant

Amenex Associates, Inc.
Suite 215 Willowbrook Lane
Westchester, PA 19382

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CAVE CAMERA EXPLODES!

Editor's note: We reprint this review and letter from Caves and Caving [issues 44 and 45], the bulletin of the British Cave Research Association. The incidents described are harrowing, costly, and perhaps dangerous.

We invite readers to send letters describing any similar events, or to write and speculate on possible causes and preventative measures.

LE CLIC ALL-WEATHER CAMERA

The TUFF 35mm Allweather camera is supposed to be built to withstand knocks and scratches and to be resistant to rain, dust and sand and it even floats according to the manufacturers press release. I duly wrote off to Keystone Cameras as UK Ltd., who market the camera in the U.K. for their parent company, and received a camera on sale or return basis for a one month trial. First impressions wer favourable. The camera has a plastic case in gunmet grey and yellow and looked quite stylish. Retailing a around £60 this camera has a number of useful feature for the non too competent photographer. It loads and re winds film automatically and has a built-in motorised wind on and flash. It has a 38mm fixed focus lens with a maximum aperature of f/5.6.

As a gear test I took the camera to Switzerland in late December last year to try out in the snow and also under the surface in quite cold conditions and initially underground results seemed quite pleasing. Towards the end of the second day underground a problem occurred of which the manufacturers have yet to provide a satisfactory explanation. We had set a shot up with several slave units and guns along the passage and I passed the camera to a companion, Hugh St. Lawrence. He framed the shot, pressed the shutter, and suddenly a violent explosion reverberated down the passage. Hugh fell to the floor followed by the camera. Fortunately he was not injured but badly shaken. Although there was no sign of external damage to the camera, it would not function even when a new set of batteries were fitted. This incident caused us a certain amount of alarm and the camera was returned to the manufacturers immediately on return to this country.

Initially they replied fairly quickly but we did not find their explanation very satisfactory. To quote from the letter — "*. . . We did find however that the camera had obviously been dropped . . .*" Of course it was dropped: when it exploded!! "*. . . It is quite possible that the explosion was caused by atmospheric circumstances in the cave. In that case the explosion would have occurred whatever camera you used and has nothing to do with our range of cameras.*" Hardly very likely as we had another camera and several flash guns with us, none of which exploded. However, they assured me that they would send the camera to their labs in the U.S. for a thorough investigation. By the middle of April I had still not received any such report even though they have been contacted by letter and several phone calls.

To add insult to injury, they said that they would send me another similar camera to try out, which has never arrived. Also, I recently received a bill for the camera which I had returned. There would seem to be a lack of communication within Keystone Cameras.

At least the 20 shots that I did take came out reasonably well, so I will leave it to the reader to decide whether to purchase the camera.

Andy Hall

EXPLODING CAMERAS

Reading the Equipment Column of *Caves & Caving 44*, I was intrigued to read of your experience with the Le Clic exploding all-weather camera (a device which, in the proper context, could doubtless have considerable novelty value) and Keystone Cameras' subsequent diagnosis of the incident; this seems something of a cop-out to say the least. I had a very similar experience in 1981 whilst we were exploring and photographing the Lower Streamway of J.K.'s (now renamed Crag) Cave in County Kerry (*C&C 15*).

We only had one flashgun, a Prinz Jupiter (a cheap manual gun made by Dixons) which Elaine (my wife) was firing on the count of three whilst I opened the shutter on B, in the time-honoured manner for amateur cave pics taken with the minimum equipment. I counted, she p;ressed the white button — and there was a stunning bang which shook the whole cave. My immediate expectation was that her arm, at least, had been blown off. Thankfully it was still attached; she was still holding the flashgun (having been too surprised to drop it) which now had its case shattered and the tube dangling out of the front on two wires. Incidentally, it was still cheerfully recycling (and still worked) — and the picture came out, showing a scatter of small illuminated dots which I take to be flying fragments of flashgun housing.

A few days later I dispatched the damaged gun to Dixons, telling them of the emotional distress that the incident had caused (I had a wife who was now less willing to function as a slave unit) and that flashguns shouldn't do things like this; I explained that the flashgun had been kept in a waterproof ammo can and that it had been dry at the time of the incident (it was the first and only photo of the trip). They replied that they considered that the keeping of the gun in an airtight canister had resulted in a build-up of hydrogen and chlorine inside the case, which had detonated on the discharge of the tube, H+Cl=HCl . . . bang! The answer might be not to carry flashguns in airtight containers. They accepted no liability but to show goodwill, rebuilt the flashgun free of charge (rather strange with a £10 item).

Has anyone else had a similar experience? If the hydrogen and chlorine theory is right then the Le Clic all-weather 35mm might itself form an airtight container around its flash unit, and be prone to explode above or below ground. But if you want real pyrotechnic fun then I know a good recipe for flash powder . . .

Peter Ryder, Moldywarps Speleo Group

HOME-BREW v. COMMERCIAL EQUIPMENT TEST

by Frank Reid and Ian Drummond.

An exciting cave-radio test was carried out at Yahoo Falls, Kentucky on May 27, 1989. Frank Reid provided a receiving system assembled from commercially available components, and we were able to compare its performance with that of the ASS cave radio receiver.

Frank's system consisted of a single-turn loop antenna and a Burhans* H-86 VLF/LF preamplifier, feeding a Burhans VLF-87 up-converter (f to f+4.000 MHz), thence to an ICOM 720A HF transceiver.

The untuned loop consisted of type 9086 coaxial cable (50 Ohm, large diameter, solid conductor) 25 ft. (7.6 m) in circumference, with a gap in the shield. (Details of construction accompany the H-86 preamp, which is mounted as part of the loop assembly).

The ASS cave radio loop was 70 turns of 28 AWG (0.32 mm dia.) on a square frame 2.84 m in circumference, tuned for resonance at 115.4 kHz. (SPELEONICS 5 gives a complete description of the ASS cave radio and antenna).

Both antennas were laid flat on the ground, and the second ASS unit was used to transmit both pulsed-tone and voice (114.3 kHz upper sideband) at increasing horizontal distances on the surface.

Background noise registered "S2 to S3" on the ICOM signal strength meter.

At 100 m, the signal was S9+5
200 m, S6.
250 m, S4.

This being the limit of two-way speech for the ASS radio. The Burhans equipment finally lost the speech contact at about 280 m.

Conclusions. The Burhans loop worked marginally better, but the loop was much bigger in area. With similar sized equipment the tuned loops will probably have slightly better performance.

The Burhans loop preamp and converter operate over 10 - 400 kHz range (lower with modifications), so variable-frequency cave radio receivers are possible with this equipment. Burhans preamps and converters are specially designed for wide dynamic range to reject strong-signal intermodulation effects (e.g., from LORAN-C). Commercial equipment could provide the basis for assembling cave radios without having to build everything from scratch, so a trade-off of time v. dollars becomes possible.

A very valuable conclusion for the designers of the ASS cave radio is that the existing circuitry is adequate, and attempts to improve its performance will probably yield only minimal gains. Home-brewed equipment can hold its own with some pretty fancy commercial stuff!

* **Burhans Electronics,** 161 Grosvenor St., Athens, Ohio, 45701, USA. See SPELEONICS No. 7, p.3 and No.11, p.8 for info on Burhans products.

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from Lexington, Kentucky Herald-Leader, 14 Dec. 1989:

SOUND SYSTEM AIDS RECOVERY OF WORLD'S LARGEST DINOSAUR

by Lee Dye, Los Angeles Times

San Francisco - New technology expected to move the tedious search for dinosaur skeletons beyond the age of the pick and shovel is helping scientists recover remnants of the longest dinosaur ever discovered.

By using seismic images of the sandstone beneath a site in New Mexico, scientists were able to detect the dark shadows of bones of Seismosaurus - so named because it was so big that when it walked, the ground must have trembled. Results of the project were presented here last week during the fall meeting of the American Geophysical Union.

Workers know precisely where to dig because of a technology developed by the federal Department of Energy to help find acceptable burial sites for waste disposal... The process is similar to computer tomography, which uses X-rays to produce images of tissues and bones inside humans, except sound waves are used...

"We call ourselves the 'Dino-busters,'" said geophysicist Alan Witten of Oak Ridge National Laboratory....

The excavation has been accelerated considerably by the technique developed by Oak Ridge's Witten and Jozef Sypniewski of Wayne State University.

The heart of the process is a shotgun on wheels, which Witten called a "cannon." "It fires a slug of soft metal into the ground," Witten said. "It hits the ground and flattens, sending out sound waves."

An array of 29 microphones lowered down a well on the other side of the site picks up the sound waves... The cannon is then moved 2 feet and the process repeated.

By plotting the time at which the sound waves are received, Witten is able to show precisely where the bones are hidden beneath the 8-foot-deep layer of sandstone... [contributed by **P.C. Magoun**, W4ULC]

-- See also SPELEONICS 8, p.15.

Reprinted from DESCENT #88, June/July 1989, p.12:

Doolin Green Holes from the surface

THE University College of Galway's Geophysics Department was alerted to the geophysical potential of the Green Holes after watching an Irish television programme about the caves. They considered that since the caves were filled with sea water, the saline content would make the water into a good conductor. Consultations followed between Kevin Barton of UCG Geophysics and Matthew Parkes of UCG Geology, Nicky Johnston of Aillwee Cave, and your *Descent* correspondent.

Fintan Convery, an MSc postgraduate student, then carried out an orientation survey from the 3rd-4th April over Mermaid's Hole. He was using Very Low Frequency Electro-Magnetic (VLF EM) equipment on the surface, to pick up the response in the sea water in the cave, and very powerful transmitters of the sort used by various countries around the world to communicate with their submerged submarines. The initial trial proved to be very successful, showing good big kicks over the passage, exactly coinciding with the surveyed position. A trial was also carried out at Gort over the deep, but large, Churn to Pollduagh section of the Cannahowna River Cave. Responses here were predictably weaker, due partly to the depth but mostly to the fact that fresh water is a poorer [illegible]

Fintan has now taken in these experiments as part of his postgraduate project, and this will be available in the Geophysics Department in October this year. In June he will be carrying out further traverses over Mermaid's Hole and will attempt to follow it inland. He expects that the response will gradually decrease, as the salt water content in the passage gets less. He will be computer modelling the results and even intends to produce passage cross-sections. He hopes to get some cave divers to collect water from different points in the cave during the next series of readings, so that he can relate the response to the saline content.

If there are any divers visiting Clare in June who would be willing to help collect samples, or if anybody else has used VLF EM 16 or other techniques to locate sumped or dry cave passages would they contact: Kevin Barton, Dept. of Geophysics, University College, Galway. Telephone from the UK: 010 353 91 24411 ext 2690.

CB RADIO FOR UNDERGROUND COMMUNICATION

by L. Sear (G3PPT)
Wheal Jane Mine, Baldhu, TRURO, Cornwall, U.K. TR3 6EE.
Condensed from Mining Magazine, August 1988, 110-111.

Radio communication in various forms adds enormously to the efficiency of operations in everyday life, and the underground mining situation cries out for such a benefit. However radio waves do not travel through rocks except at very low frequencies, and then only to a limited extent. The commercial systems available overcome these limitations imposed by the laws of physics by routing the communication to where it is needed by some form of feeder (Mining Magazine, Feb. 1988, p123-127).

At low and very low frequencies this feeder can take the form of a simple insulated wire ... , whereas at high and very high frequencies specially designed coaxial cables are used which "leak" signal in and out and allow simple "walky-talky" type sets to operate within direct sight of the cable. ...

CB Radio.

... 27 MHz CB radios were introduced, initially by illegal means, into the UK during the early years of this decade. ... One advantage turned out to be the availability of extremely cheap equipment mass-produced in the Far East ... . Experiments soon showed that 27 MHz radio signals become attenuated to zero in tunnels. However all was not lost because 27 MHz is well suited for a leaky cable system.

The coaxial cable used in leaky cable systems is specially designed, and hence expensive, and it occurred to the author that the very cheap flat twin feeder also widely used in radio engineering (for example as domestic TV antenna cable. --Ed.) might leak sufficiently at CB radio frequency to act as ultra-cheap leaky cable. Initial experiments were conducted using a pair of "DNT" CB rigs converted to use in the 10 m amateur band (28.0 - 29.7 MHz). These were used in the 0.5 W power position, one as a fixed station connected to a length of 75 ohm flat twin feeder routed through the area of the required communication and terminated with a 75 ohm resistor, and the other as a portable station with a helically wound dipole as antenna. (The author suggests in a caption to a photo, that a flexible rubber antenna would be more convenient. --Ed.)

Tests.

A number of experiments were carried out at the Wheal Jane and South Crofty mines and these showed that reliable communication was possible so long as the portable station was within line of sight of the cable at some point.

Typical of these experiments was one which took place at the Mount Wellington section of the Wheal Jane mine: the base station was located at the 6 Level shaft station and 350 m of 75 ohm flat twin feeder laid out along a fairly tortuous route and terminated some 10 m inside a typical stope. Excellent communication was obtained all along the total length of the feeder and through out the stope area, only petering out at the remote end of the stope where the structure became constricted. Some idea of the ultimate range of the system was gained during this experiment when resistive attenuators were switched into the feeder at the base station end, and it was found possible to insert 50 dB of attenuation before signal degradation became at all apparent. This infers a range of 1 to 2 km since attenuation of the flat twin cable is approximately 7 dB/100 m at 27 MHz. ... .

Equipment.

Clearly, consumer-oriented equipment is not, as it stands, suitable for the rigours of conditions underground in most mines. However by encapsulation inside suitable protective housing, the equipment may be sufficiently protected so as to allow a reasonable life. ... (The author here describes a permanent installation on the Clemows Shaft at the Wheal Jane mine. --Ed.) ... .

The Legal Position.

The use of CB equipment in the UK is subject to a number of technical constraints in the form of power limitation and the type of antenna used. In addition, only type-approved equipment is allowed. The use of long feeders to a dummy load as shown here, while innocuous enough, is not allowed for in the current (UK) CB legislation. However the Dept. of Trade and Industry is willing to consider issuing a variation to the terms of an individual CB licence, on application. Users in other countries should consult their own authorities. ... .

Safety.

The possibility of radio frequency interference to electrical detonator circuits should always be borne in mind. In the experiments described, the power was limited to the 0.5 W available in the "low power" position of the particular equipment used. The cable presents no problem as it is terminated by a resistive load and radiates only "leakage," and in any case the inherent attenuation of the cable rapidly reduces the power available at any position remote from the transmitter. The portable equipment should also present no problem, but should be selected to be as low in power as possible. If a mobile type is fitted in a trackless vehicle in a decline, for instance, then this should be hard-wired in the low power position. British Standard BS4992 states that mobile radio of any frequency with a maximum transmitted power of less than 10 W presents no hazard provided no direct contact is made with the antenna, whilst the Nobel's Explosive Company calculates that the safe distance for a 27 MHz transmission of 2 W effective radiated power is 6 m. A voluntary ban on use of the portable transmitter within, say, 25 m of detonator circuitry would seem expedient.

Conclusion.

What has been described is essentially a poor man's (or mine's) leaky cable system. ... The principle ... would even be cheap enough for the speleologist.

... The author would welcome feed-back from anyone trying out the ideas outlined in this article.

Electronics in action ....

from an article by **Mervyn Mitchell** in the Canadian Caver, Fall 1989, 37-40.

Editor's note: "Close to the Edge" is a deep cave in the northern Canadian Rocky Mountains. The first pit is 244 m [820 ft] broken only by a rebelay ledge at 130 m [425 ft]. The second pit is 32 m [110 ft] ending at a crack 10 cm [4"] wide carrying a howling draught, and apparently opening into a further shaft. At the time of this trip the cave had been bottomed only twice before, in 1986 by a Canadian team, and in 1988 by an American group.

This account is of the third descent by a crew determined to pass the crack at the base of the final shaft.

Speleonics readers may be interested in the combined use of explosives and guide-wire communications in an exciting and dynamic environment.

--

...The shaft was dropped on Tuesday, first by Ron, with Gille and Merv following. Apart from the ledge, the rope hangs about 5-10m from the sides all the way down. It's a classic rappel, starting in daylight, and descending into the deepening gloom. Voices carry but with a booming resonance that blends with the noise of falling water to make verbal communication impossible over any distance.

Given our objectives, which included the use of explosives, we had decided that clear communications from top to bottom were imperative at all times. Following upon a suggestion made by Ian Drummond, we had experimented with low power walkie-talkies and a leaky antenna during the July mock-rescue in Thanksgiving Cave. A small CB unit used reasonably close to an insulated wire laid through the cave will communicate clearly, and over an apparently indefinite distance, with other CB units similarly placed.

Uncertain of the effects that blasting, even with small charges, might have upon the inherently unstable rock close to the top of the shaft, we decided that no shots would be fired until all cavers were out, and the ropes withdrawn. This entailed laying 350m of blasting wire from the surface to the charges and presto.. there was our antenna. We had, of course, reckoned without the ability of copper wire to tie itself into vast and labyrinthine tangles, or to wrap itself in tight coils around the climbing rope, but otherwise, the system transcended our best expectations...

From the base of the main shaft, a narrower one drops about 30m more to a small chamber and THE CRACK. There hours of digging led downwards, first through larger rocks, and then into a frozen matrix of rocks, gravel and clay. Heavy Going! After about 1.5m, we decided to lay charges, but with no serious expectation of enlarging the opening enough to allow access. At this point, I recall we felt pretty discouraged. A single cap was connected to the line, buried under a rock, and the surface crew instructed to detonate it to check the circuits. The explosion sounded pretty loud in the confined cavern. But the shaft evidently acted like a gigantic phonograph horn, and the sound emerged on top as a gigantic BOOOOOOOM. The same thought impaled every mind. "Oh ****! They've blown their dynamite." But, of course, they hadn't. Phew!

On the way up, each climber in turn had to wrestle with the blasting wire entwined around the climbing rope. Merv managed to cut it free in several places and re-splice and rewrap it, but by the time he reached the ledge, he was too cold and wet to finish the job. It's a long grunt out (like doing 800 push-ups on a water bed, according to Gille) but somehow the cold beer, hot soup and blazing fire that awaited each caver made it seem worthwhile, especially in retrospect.

Dale and Rick descended on day 3. By pre-arrangement, the rest of had scattered ourselves wherever we could get a decent view of the country below the cave entrance. At midday, Dale let off several smoke bombs by the crack, while we watched for emerging smoke (a technique that was used semi-successfully at Thanksgiving last winter).

No smoke was seen. Too bad; a lower, walk-in entrance would have nicely rounded off the trip.

Dale and Rick reset the charges, tamping them with masses of clay which lay in a pile nearby. Before we detonated that night, one or two souls made themselves scarce; after all, they probably reasoned, if one cap can make that much bang, what will the dynamite do? As it was, the anticipated explosion was scarcely a hiccup - probably on account of the heavy clay packing, and nothing was dislodged from the shaft as a result of it...

Day 4 started auspiciously. In the middle of breakfast, Steve Cutts "dropped by" with 24 cold beer, fresh cream, ground coffee (the real stuff) and lots of toilet paper; all the things he felt we might be short of. If I had any say in these matters, I'd canonise him.

Trundling alongside Steve came Jean-Pierre Boivin, who'd wandered into Prince George the day before, looking for some caves. He should have known better. By midday, we'd lowered the ropes again and Jean-Pierre and Dave were on the bottom, enthusiastically reporting in a polyglot mixture of English and French that the blasting had removed plenty of rubble. Some hours of hard digging through loosened rock and clay brought then to a constriction abut 15cm wide, but affording a clear view of larger spaces beyond - probably the other side of a shaft, about 25m away. About 30cm to go, and best of all, rocks tossed through took 3-4 seconds to hit bottom. Or maybe just a ledge? One more blast should get us through.

So Gille was despatched downwards with more dynamite. But as he descended, gigantic cumulonimbus clouds massed around the setting sun and within an hour, the thunder rolled in from the southwest. As the celestial fireworks approached, Merv, who was left on radio duty, decided that three cavers and lots of high explosive at the end of 400m of lightning conductor were not conducive to safety, so he aborted the blasting and called a rout.

By day 5, both time and the inclination to further vertical work were running short So we pulled, inspected and coiled the ropes and blasting line...

By Saturday afternoon, everyone was off the mountain, and those who returned to Prince George celebrated in appropriate style.

We did not entirely achieve our objective, but all the same, we came far closer to doing so than any of us truly expected. It would seem probably that Close to the Edge continues downwards - how far we can only guess - but as far again as the depth of the main shaft is entirely possible. It is dangerous to tempt providence - or whatever goddess is rash enough to look after the interests of cavers - by making optimistic predictions, but a further expedition will almost certainly add significantly to the depth of this cave (already number 8 in Canada), and may open up a major new system. The dates for a return trip in 1990 have already been set.

Although not as deep as some of the Mexican shafts, the hazards of Close to the Edge should not be underestimated. It's a cold, wet cave and prone to sudden unavoidable rock and ice falls. We counted eight But just to see the entrance is a thrilling experience, and the shaft offers one of the greatest rappel experiences available anywhere. Anyone seriously contemplating an expedition should first talk to someone who has already been down.

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REPRINT of a report of historic interest concerning single-sideband radios and the use of guide-wires.

As many of our readers know, in the early 1960's induction cave radio equipment was developed, virtually independently, in South Africa, the United States, Britain, and possibly elsewhere. Most equipment operated directly at audio frequencies and consequently suffered from terrible interference from external noise, both natural and man-made. By the late 1960's the development of two different methods of overcoming the noise problem was underway.

In the USA very narrow-bandwidth audio frequency equipment was developed for use primarily for position-location work.

For cavers in Britain (and also for mining interests in South Africa) the solution was to use single-sideband (SSB) equipment operating at approx. 100 kHz, taking advantage of the lower background noise to retain a bandwidth of approx. 2 kHz, wide enough for speech.

To build such equipment was a significant undertaking for cavers, the equipment is complex and expensive, and sucess might have seemed uncertain as the higher frequency fields are attenuated more quickly than the audio frequencies by the conductive rock.

No doubt the field trials described below, demonstrating the successful use of SSB equipment operating at 100 kHz, provided some assurance that the projects would work, and gave some of the impetus needed for the British cavers in the 1970's to develop projects such as those by Makin and Glover, and by Hart. In turn these projects have given the communication equipment routinely used by British cave rescue organizations in the 1980's.

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THE CAVE RESEARCH GROUP NEWSLETTER 107
Sept. 1967. p4-6.

The 1967 Ingleborough Field Meet Report

by R.R.Glover

Induction Communication Systems in Caves

We were very fortunate to be joined for two days of the meet by David Pratt and Laurie White, Chief Engineer and Chief Project Engineer respectively of Spembley Electronics of Andover. They bought with them a range of magnetic induction communication equipment under development by their Company, and were interested in investigating the performance of the equipment in an underground environment.

The principle of magnetic induction communication in caves for both surveying and speech has been demonstrated by Birchenough and Lord, but most of their work was carried out at low audio frequencies.

The particular interests of Spembley Electronics lie in the development of various types of two-way communication systems using this inductive or "near-field" technique. Using low radio frequencies (approx. 100 Kc/s) tuned, flexible, printed circuit aerial loops and transistorized amplifiers, their inductive Manpack Transceiver forms the basis (with suitable modification to detail) of a feasible Cave Rescue Communication system when used with a guide wire.

The 1/2 watt Manpack transceiver has a maximum free space range of 150 ft (46 m). No measurable attenuation was introduced when in the cave. When used closer than 8 ft (2.5 m) to a guide wire running through the cave, (one end of which was earthed to the lighting system, the other end bared and dropped in a static pool of water), the signal level appeared as high as if the sets were within 10 - 20 ft (3 - 6 m) of each other, no matter how far apart they really were. Perfect two-way communication was established in this way from one end of the show-cave section to the other. It would appear that when used in this fashion, the maximum range is likely to be over 2 miles (3 km), whilst in shallow cave systems direct communication with the surface would be possible without a guide wire. Pratt and White also bought with them two larger and more powerful transceivers, originally designed for use in vehicles, but modified to be portable. These sets, operating at the same low radio frequency as the manpack sets, transmitted 4 watts of single side band power into a tuned loop aerial 3 ft (0.9 m) across. The free space range of these sets was of the order of 600 ft (180 m); and they were therefore of adequate power to be used for magnetic survey trials.

Accordingly one set was taken into Ingleborough cave and attempts made to obtain surface fixes of the locations of the Mushroom Beds and the Abyss. Initially, we had no success. It was not possible to find any one point giving a convincing null with the receiving aerial held vertically and rotated. Eric Hensler saved the day by suggesting that the failure could be due to the guide wire installed in the show section of the cave, still connected from the previous tests. This suggestion was, thanks to the ability to talk to the party below ground, passed on and the guide wire circuit broken. Immediately it became possible to obtain a good fix of the underground aerial to an accuracy of under 5 ft (1.5 m).

After making and breaking the guide wire while transmitting from in the cave while the receiver was used to explore the related changes in field pattern, it became clear that the guide wire circuit, when complete, generated its own magnetic field which was in this case intense enough to blur or "fill in" the signal null obtained when the receiver aerial was parallel to the guide wire. Magnetic survey location cannot therefore be carried out in the presence of a completed guide wire circuit.

The following day, the batteries of the 4 watt sets having meanwhile been recharged, one was carried into the cave as far as Giant's Hall and the aerial set horizontally as accurately as could be checked by spirit level. Within a few minutes of arriving overhead with the other set, an accurate fix was obtained. Here again, the two way speech facility proved invaluable in arranging details of the tests. Without voice communication with the underground party, we could well have spent many hours without being certain that we were in the right place. A cairn was constructed at the indicated position, this being (to within 5 ft (1.5 m)) directly above the highest point of the floor of Giant's Hall. The position of the cairn was found by surveying later to agree with that given by the Nolan-BPC survey of Ingleborough Cave to within the limits of plotting error ... .

An estimate of the depth to the transmitter was made by finding the point (at the same level as the cairn) at which the magnetic field was inclined at an angle of 45° (estimated by eye) to the horizontal. This was found to be 132 ft (40.2 m) from the cairn. Analysis of the radiation field pattern from a short dipole gives a simple equation relating depth of dipole to distance from the vertical and angle of lines of force. ... Using the formula in this case gives a figure of 235 +/- 15 ft (71.6 +/- 4.6 m) for the depth of the floor of Giant's Hall below the cairn. The side limits of error are due to the likely error in estimating by eye an angle of 45° to the horizontal.

All of us who assisted David Pratt and Laurie White in this work were very impressed by the performance of the manpack and 4 watt sets under cave conditions, and we are very grateful to them for spending so much time, effort and expense on our behalf. Both pieces of equipment are likely to play an important part in stimulating the development of communication techniques in Cave Rescue and Cave Survey in this country.

JAMES R. WAIT - SENIOR THEORIST OF CAVE RADIO

Anyone interested in the theoretical basis of underground radio, presented in a clear, practical manner, should be aware of the work of James R. Wait. He obtained his PhD in 1951 from Toronto in Canada and worked for Newmont Exploration, then Defence Research Telecommunications in Ottawa, and in 1955 moved to Boulder, Colorado, with the National Bureau of Standards. He helped establish the journal Radio Science, being editor of it as well as J. Geophysical Research and Electronics Letters. His list of awards and visiting professorships around the world is most impressive.

In the mid-80's when many people might be thinking of retiring, he left the govt. and joined the University of Arizona in Tucson. He was consulting for Schlumberger, the multi-national geophysical firm, when my letter caught up to him. I had written to him requesting a reprint of some detailed calculations of the magnetic field around a buried loop antenna. I not only received the reprint, but also a hand-written letter, and a list of his publications since 1970 where he had taken the trouble to circle the ones relevant to the problem I was working on. What was truly startling was the volume of publications; the list ran through to No 712 in 1984. I make that one scientific paper in a peer-reviewed journal every 2 1/2 weeks for 34 years, plus a couple of books!!

I suppose it was hardly surprising to find relevant Wait papers when I was assembling material for this issue of Speleonics on leaky feeders underground.

It certainly is a pleasure to me to spend the occasional weekend in the University library looking for ideas on cave radios in the work of J.R. Wait.

--Ian Drummond

IMPULSE-RADAR TECHNOLOGY MAY YIELD "CAVE SCOPE."

Aviation Week & Space Technology magazine* reports that "ultra-wide-band" (UWB) radar can see through water and earth with resolution of a few centimeters. AWST advocates high-priority government-financed research and development of UWB radar for stealth-aircraft detection and other military advantages.

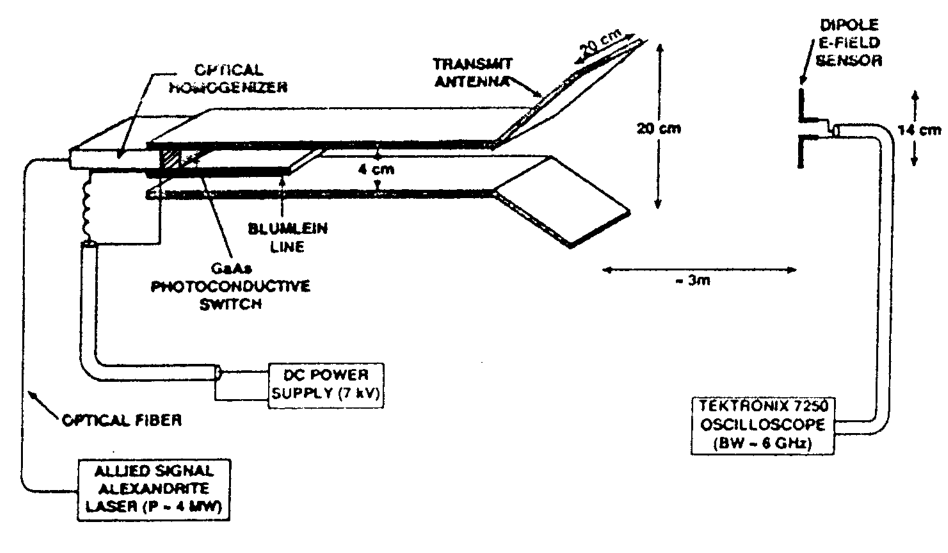
A synthetic-aperture radar experiment on an early Space Shuttle flight discovered ancient river beds covered by Sahara Desert sand. Rumors persist of military-secret radars which can see submarines, missile silos, and North Korean tunnels under the "demilitarized" zone.

The AWST article predicts numerous commercial spinoffs of UWB radar technology. One of these may be greatly improved ground-penetrating radar, allowing us to discover the entranceless caves which some theories predict outnumber all caves now known (see editorial in SPELEONICS 4).

Conventional radar transmits short bursts of discrete-frequency microwaves. "Impulse" radar uses extremely powerful single electromagnetic pulses of less than one nanosecond duration, having frequency components from "near DC" to several gigahertz.

Commercially-available ground-penetrating radars for geological applications transmit single cycles of VHF or UHF. An impulse generator like the one illustrated in the AWST article (below) might be useful for looking into the earth with improved range and resolution, using conventional time-domain reflectometer circuitry or more sophisticated signal processing. -- Frank Reid

* Scott, William B. "UWB Radar Has Potential to Detect Stealth Aircraft" Aviation Week & Space Technology, 4 December 1989, p. 38.



University of Texas at Arlington's impulse transmitter featured an 8-element array of photoconductive switches activated by laser pulses. The resulting electromagnetic pulse propagated down the 4-cm. channel and radiated to free-space. A dipole sensor detected a 400-picosec. wideband field pulse having a peak power of about 800 kw.

dah-dah...dah-dah...dah-dah..dah-dah...

BAT PHONE

by Paul Johnston, KA5FYI *

Have you ever wondered what the bats are saying about you when you were in a cave with them? Wonder no more! I came across an article[1] that shows how to build a simple ultrasonic receiver from readily available parts or in kit form. It will take you only a couple of hours.

I have always wondered what a bat's voice sounded like, but have been able only to catch a high-pitched peep or two. The reason is that much of what they say is in the ultrasonic range; that is, above human hearing capability. The BAT PHONE (my own name for this ultrasonic receiver) converts these ultrasonic sounds down to an audio frequency that humans can hear.

As soon as I built the BAT PHONE, I headed down to the Congress Avenue bridge in Austin where a large colony of bats live, and listened and watched the evening bat flight. I attached a portable tape recorder to the ultrasonic receiver and recorded the bats' voices. Now when I tire of listening to heavy metal or c&w, I can switch on my tape of ultrasonic new-wave peep, squeek and flap.

The BAT PHONE is built on a small circuit board, powered by a 9-volt battery and housed in a piece of 4-inch [10 cm] diameter plastic pipe 7.5" [19 cm] long. The microphone is a 3.75" [9.5 cm] diameter piezo loudspeaker on one end of the pipe. The controls and headphone jack are mounted on the other end of the pipe. My stereo headphones worked fine. Stenographer's headphones also work.

To use the BAT PHONE, all one has to do is turn it on, adjust volume, point to where you want to listen, and adjust the tuning knob to a sound you enjoy listening to. What amazed me is all of the ultrasonic sound that is around, that you cannot hear. A large colony of bats may seem relatively quiet without the ultrasonic receiver, but turn the receiver on and listen, and you will think you are in a cage with hundreds of parakeets.

Besides bat talk, you can listen to small air leaks, electrical arcing on power poles (handy if you are having electrical interference with radio receivers), the unique noise that running water makes, the screens of televisions or computer monitors, the strange noises of mechanical devices, and the sounds of birds and insects that you normally would not hear.

Overall, I think you will find this project to be simple, low cost, and will broaden your awareness of the unheard sounds that are always around you.

TECHNICAL NOTES

If you build the BAT PHONE from the article instead of buying the kit, there are a few corrections: Capacitor C3 shown on the schematic drawing should be a 47 microfarad instead of that shown. The pictorial showing parts placement (Figure 3, page 48) shows transistors Q1, Q2 and Q3 oriented incorrectly. These three parts should be rotated 180 degrees from what is shown.

Kit corrections: The printed circuit board that I had received had pins 13 and 14 of U2 connecting. The schematic drawing shows no such connection, so I scratched a small line between these points, thereby eliminating the incorrect connection.

The only additional parts that the kit does not supply are a piezo speaker, battery and holder, wire and solder, and a small piece of metal to make a bracket. (I cut one from a tin can). I also added an additional phone jack for a second set of headphones or tape recorder.

One person[3] found that his receiver would tune to 12-21 kHz instead of the 15-35 kHz claimed in the article. He found that by substituting a 2200 ohm resistor for R5, it expanded the tuning range to 15-66 kHz.

References

1. Charles D. Rakes, "The Ultrasonic Receiver," Popular Electronics, Feb. 1989 pp.46-48, p.103.

2. Krystal Kits, P.O. Box 445, Bentonville, Arkansas 72712. $34.95 postpaid.

3. B.P., Oswego, IL., "Letters," Popular Electronics, September 1989 p.4.

See also: "Notes on bats and ultrasonic translators," SPELEONICS 13, p.7. Our apologies for not including this article in the last issue. --ed

* 207 West Crestland Drive
Austin, Texas 78752

Book Review

Crystal Oscillator Circuits by R.J.Matthys. Wiley and Sons, 1983, ISBN 0-471-87401-9.

This is a very practical book; it describes many types of crystal oscillator circuits with the underlying design criteria, then summarizes in table form the advantages and disadvantages of each circuit. The author has then constructed each circuit operating at three different frequencies (1, 10, and 100 MHz) and presents photographs of the output waveforms, as well as tests for sensitivity to cold, heat, and supply voltage. An example of the useful information to be found is a table where the effects of various ways to trim the frequency of an oscillator are summarized.

I used the data in the book to make an oscillator for CB crystals, the commonly available third-harmonic crystals which operate near 27 MHz. I used the Colpitts design in a circuit that ensures the crystal oscillates at the harmonic frequency, rather than the common but cruder method of operating the crystal at its fundamental and driving a resonant tank circuit, a method which produces poorer waveforms and much more noise. That is just one example of the nice touches and useful information found throughout this book.

--Ian Drummond

[**Continued** on back cover.]