speleonics 12

APRIL 1989

"BETTER CAVING THROUGH ELECTRICAL STUFF"

volume III number 4

[photo by **Harold Pruitt**]

THE BRIEF COLLABORATION BETWEEN ALFRED NOBEL AND THOMAS EDISON

or

THERE IS NO NOBEL PRIZE FOR SPELEOLOGY

Sam Frushour (L) and **John Hartman** re-enact a technically-correct version of a cartoon from The New Yorker magazine (7 November 1988, p. 154). Antique equipment: Hurcules(tm) 50-cap blasting machine and General Electric Mazda(tm) tungsten-filament lamp. We cheated to preserve the bulb (from **Angelo George**'s garage sale)-- It's actually connected through a triac lamp-dimmer to the lights in the commercial section of **Cumberland Caverns**, Tennessee.

Cartoon blasting machines are nitroglycerine pumps but real ones are electric generators. The rack-gear plunger spins a flywheel, and closes the circuit when it reaches the bottom of its stroke. The output can light a 115V 100-Watt bulb for one second. Mechanical blasting-machines are being supplanted by compact (but less dramatic) capacitor-discharge electronic types containing dc-dc converters. The machine in the picture weighs 22 pounds (10 kg). We don't recommend this system for cave lighting! Fortunately, product-liability lawsuits were rare in Nobel's day. On the other hand, consider the case of Coyote vs. Acme!

SPELEONICS 12
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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, $6.00 overseas.** Send subscriptions to section treasurer **Joe Giddens** at the address below (make checks payable to SPELEONICS). If you have a ham-radio callsign or NSS membership number, please include them when subscribing.

Foreign subscriptions can be paid in U.S. "paper" dollars in the mail; an international money-order may cost as much as the subscription. 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 are mailed to NSS offices and sections, the U.S. Bureau of Mines, U.S. Geological Survey, and the Longwave Club of America.

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Editorial - As we end our third volume, it is gratifying to note that Speleonics has become self-generating-- For the first time we have a backlog of articles from many contributors. We hope to keep the gestation period reasonable by publishing more issues per year if necessary. We are experimenting with new software, hoping to enhance the print quality of future issues.

--Frank Reid

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NEWS AND ANNOUNCEMENTS

INFORMAL SPRING MEETINGS. All Speleonics readers, cavers, VLF/LF experimenters, and interested people are invited to our second annual meeting at the **DAYTON HAMVENTION** (Dayton, Ohio) at 11:00am local time on Saturday, April 29. Place: Seats (!) above main arena (the "big room" containing major manufacturers' displays), South corner behind DARA booth (to right of main entrance), top level. A carbide lamp will mark the spot. Show/tell, trade equipment, share information (including flea-market locations of interesting items) or just say hello. Bring lunch if you wish (recommended; hamfest food is awful! :-(* Freq: 147.64 MHz, RFI permitting.

Bring cave radios and other electronics to **KENTUCKY SPELEOFEST** (Memorial Day weekend, 26-29 May, near Whitley City, KY). **Ian Drummond** from Canada plans to attend; we may be able to assemble all the section officers for the first time! See NSS News or contact **Frank Reid** for details. Freq: 146.66 MHz simplex.

"FREEDOM OF THE PRESS BELONGS TO HIM WHO OWNS ONE."
-- St. Wysiwyg of Gdansk

Diana George, or regular publisher, has been unable to print the last two issues of SPELEONICS due to heavy workloads of the primary users of the press. We are presently using facilities of higher cost and lower quality.

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[Continued p. 3]

AUSTRALIAN RESCUE USES CAVE RADIO

We were fortunate to have our induction radio for the 88 Pannikin Plains Cave cave-diving expedition on the Nullarbor Plains, Australia when a deluge of rain caused a collapse of the cave's entrance trapping 13 of us inside. Without the communications, the uncertainty of not knowing that everyone had escaped the rock collapse and being able to coordinate rescue teams, the situation would have been far more severe.

Although the report was not written for Speleonics it may help add some weight to the use of cave communications expecially when you need it most.

Ron Allum
18 Riverglen Drive
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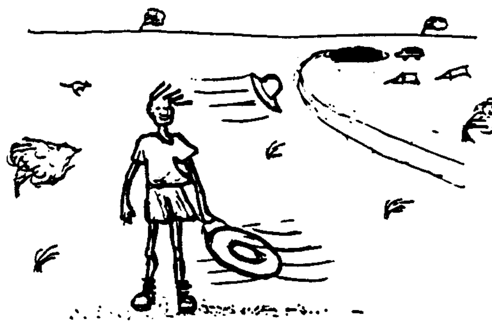
AUSTRALIA



Strong winds prevent R.D.F. reception.

Erroneous rumors preceeding Ron's letter said that a British "MoleFone" had been used. Details of Ron's equipment were published in SPELEONICS 4. A condensation of Ron's report and newspaper coverage follows. The complete articles are available from Frank Reid for SASE.

Sunday Observer (Victoria) 4 December 1988 p. 1:

Nullarbor rescue mission

CAVE-IN
13 SAVED

by Paul Daley and Ken Burrowes

Rescue workers late last night freed the last of 13 dives trapped for 24 hours by a cave-in 90 metres below the Nullarbor Plain.

The divers were filming a documentary on the system of caverns near Cocklebiddy, near the south-western tip of the plain, when a sudden severe storm dislodged rocks blocking the cave entrance.

Police spokesman Inspector David Tree said the rescue was carried out under extremely dangerous conditions. "It was raining and freezing cold and we were worried there would be another cave-in at any time," he said.

The 10 men and three women were trapped when a freak "hurricane" blocked their only exit from the cave at about 6.30pm (local time) on Friday.

The group of 18 was made up of two Americans, one Briton, six from Sydney, eight from Adelaide and one from the Gold Coast. Members of the group, described as "some of the most experienced cave-diving people in the world," were removing equipment after finishing a three-week expedition...

Two of the group scrambled to the surface as rocks began to fill the perpendicular shaft to the cavern. They joined three team members who had stayed outside the entrance and raised the alarm.

The trapped divers were able to communicate with those working above the ground, using a specially-developed radio designed to transmit through as much as 250 metres of rock.

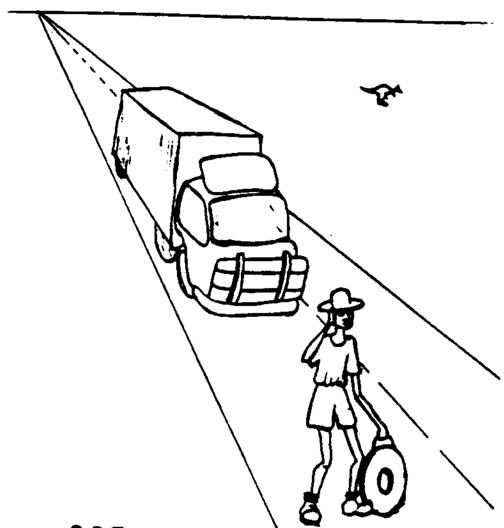
The documentary crew includes people who in 1983 broke the world record in cave diving distance in the same system of caves...

THE PANNIKINS PLAINS CAVE DIVING EXPEDITION 1988
Incident Report

by Ron Allum

The Pannikins Plains Cave Diving Expedition 1988 experienced an exceptionally strong weather occurrence only minutes after the final cave dive of a very successful expedition. Cyclonic-force winds lashed the camp and 100mm of rain was dumped in less than 20 minutes causing extensive damage, the result of which posed serious threat to the lives of some expedition members. The entrance to the cave, being the most low-lying area for several kilometres, became the drain for the flood waters. A 360-degree waterfall poured into the cave entrance.

...Ironically this was the expedition's final dive, irrespective of this occurrence. From "Concorde Landing" (an inner air space used as an advanced base) they brought with them the last remaining equipment, leftover food, water (cave water is to saline to drink), warm clothing, bedding, communications unit, radio direction finder etc.



- R.D.F HAZARD -
locating the position of Concorde Landing - under the only sign of civilisation on the Nullarbor Desert.

Thirteen people grouped together at the lake side to witness this phenomenal process of nature. Concern then existed for the safety of the remaining expedition members, however to attempt to ascend the subsiding rockpile to go to their aid would not be not 'bravado' but 'suicidal'. A 240v power cable, telephone line and a copper air hose linking this chamber with the surface were severed during the collapse.

The cave dwellers prepared for the inevitable, although safe beneath the solid cave roof. A stock take of our provisions was made, warm clothing and bedding was shared as evenly as possible, food and water supplies if rationed would last several days, cave lights were also conserved...

8am, 12 noon, 4pm and 8pm had been the routine communications schedules when we had divers at Concorde Landing. This equipment now with us, the 30m-diameter aerial was laid out in the lake chamber, hoping that the surface party would connect the topside equipment to an aerial which already lay on the surface directly overhead. There was no schedule for... communication from where we were. Fortunately, the surface had taken the initiative to set up their equipment and at 9am, as if by schedule, the first voices from the surface were received. 'Surface to Chamber, over'. The first transmission from the cave responded 'Yes surface this is chamber, there are 13 of us; who is on the surface? over'. Surface replies and lists 5 names, everybody was accounted for and were safe. The solemn atmosphere instantly disappeared and the task of assessing the situation started. Curiosity at times took over and graphic descriptions of the storm and the rock fall were also exchanged.

On the surface the camp was flattened and very wet. At 10pm a contact list of relatives was transmitted to the surface. By now it was realised that we could be here for days... Thoughts of using the RDF to locate the most suitable position to drill a hole were discussed. At 11pm, apart from receiving an update of the rescue organization happening above we were content to keep away from the still collapsing rockpile, at least for tonight. The next communications schedule was made for 7am.

Progressive assessments were made through the morning, coordinating movement via the communication system. Eventually common ground was sighted and a plan for the first person to exit was made. The first person was out at 4pm, 24 hours after the first rainfall. The other returned, carrying a pack of warm clothing brought in by the rescuers in case there may be some inadvertent delay for the remainder to exit.

Progress of the exit was checked every 30 minutes using the communication system. The final communication was at 7.15pm, the last person was on the surface at 7.45pm. The cave was clear of all rescuers at 8.15pm.

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NEWS AND ANNOUNCEMENTS [continued from p. 1]

"RADIO PIT" OPENED. **Doug Medville**'s article in <u>DC Speleograph</u> (January 1988) describes digging and blasting a new entrance into a remote area of the Friar's Hole/ Canadian Hole cave system in West Virginia, based upon radiolocations which **Ian Drummond** made in 1983. The new entrance began at an air-blowing pit 10 feet from the radiolocation. "Four years later we got in. That's the bottom line. We worked like hell and literally fought for almost every foot of the way until the final connection was made on July 18, 1987." An account of the actual connection appears in <u>The Canadian Caver</u>, Spring 1988.

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CAVE RESCUE ON NETWORK TV. Indiana cavers re-enacted a 1985 cave rescue for CBS Television, to be aired sometime in May as part of a 3-part series entitled "911 Rescue." The cave segment will be 10-15 minutes long.

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SUPER LEDs TO BE AVAILABLE AT NSS CONVENTION

John Halleck has experimented with the new "super bright" light-emitting diodes for use as emergency cave lights, using Radio Shack's 2000-millicandela units (normal LEDs are 200-500 mcd). Hewlett-Packard plans to market new LEDs in June, with outputs up to 10,000 mcd. John has arranged to buy a quantity of these, and plans to make them available at the convention.

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CALL FOR PAPERS Our annual technical session and section meeting at the NSS convention (July 31-August 4, Sewanee, Tennessee) will feature formal and informal presentations, the main difference being that abstracts of the formal papers are published in the <u>NSS Bulletin</u>. Send abstracts to **Frank Reid** (address p. 1) as soon as possible; indicate what audio-visual equipment you will need. The abstract deadline and session date have not yet been announced (see forthcoming issues of <u>NSS News</u>).

LETTERS

Our rescue organization needs cave radios! Has anyone produced a single-sided printed circuit layout for Ray Cole's "Organ Cave Radio" [Speleonics 3]?

Dave Ursin
953 East 400 South
Kaysville, Utah 84037

--

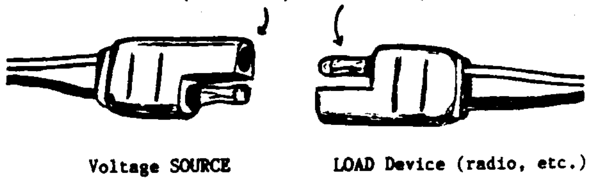
RIGHT WAY, WRONG WAY, TEXAS WAY!

Dear Frank,

I would like to jump into the controversy over which way to wire a "standard" two-pin DC connector for radios and other accessories ("Communications Standard #1.0", Speleonics 2; Letter from Duke McMullan N5GAX, Speleonics 11). Basically, y'all picked the wrong kind of connector!

A better choice than Cinch-Jones plugs (or the Radio Shack attempted copy) would be the automotive-type male/female connection pictured here.

Positive (insulated) Positive (doesn't matter)



Voltage SOURCE LOAD Device (radio, etc.)

These are available widely in most auto-parts stores, and wiring polarity is intuitively dictated by safety considerations through our negative-ground universe (I've heard tell of positive- ground automobiles but I've never seen one) as follows:

The voltage SOURCE connector (i.e., battery, power supply) has positive on the rubber-covered (female)

[continued p. 8]

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Magnetic Moments no. 9:

GROUND CONDUCTIVITY BY ELECTRO-MAGNETIC (EM) METHODS

Ian Drummond

Since the editorial in Speleonics 8 about searching for caves by measuring ground conductivity, I have had some correspondence with cavers doing just that. Also, the second newsletter of the British Cave Research Assoc. (BCRA) cave radio group has an article on conductivity (or resistivity) techniques [reprinted in this issue; Speleonics 11, p.1 has an announcement on the BCRA newsletter.]

Both groups were concerned with the traditional current-injection method, where an array of four electrodes are inserted in the ground. An electrical current (AC usually, but DC can be used) is injected via two electrodes, and voltage is measured across the other two.

As discussed in the Speleonics 8 editorial, EM methods of measuring conductivity appear to offer some significant advantages by increasing speed of measurement in the field. This issue of Magnetic Moments will look at some of the principles underlying EM methods, and suggest a particular scheme which looks easy to implement with existing cave-radio equipment.

First, consider a transmitting loop lying flat on the ground (Fig 1). The primary magnetic field is the familiar shape shown in the figure, however the current in the coil will induce eddy currents in the conductive ground. These eddy currents will, like those in any inductive load, be 90° out-of-phase behind the current in the primary coil, and will give rise to a secondary magnetic field (Fig 2).

Consider then the magnetic field at a point on the surface to one side of the transmitting loop. It consists of two components, the vertical primary field, and a secondary field which has both vertical and horizontal components and is 90° out-of-phase with the primary field.

J.R. Wait has published equations describing the strength of the magnetic field in those circumstances. (Mutual electromagnetic coupling of loops over a homogenous ground. Geophysics, Vol. XX, no.3, July 1955, pp. 630-637)

Given this basic information, there are several ways to estimate the ground conductivity.

Most straightforwardly, using a calibrated transmitter and a calibrated receiver, the value of the mutual impedance can be measured from total field strength, to allow calculation of the conductivity.

Using more sophisticated equipment with a phase-locked receiver, the value of the secondary field only can be measured, allowing more discriminating estimation of the conductivity.

Both such methods (and others, for all I know) are in use in commercial equipment, as reported for instance, in "Geophysical Techniques for sensing buried wastes" Benson, Glaccum and Noel; Report EPA-600/7-84-064. US Environmental Protection Agency.

Both methods are also difficult to implement with existing cave radio equipment, therefore I spent some time thinking abut Wait's equations to see if his results could be adapted to use with cave radios. The following method has not been tried practically, but seems to have a lot of promise.

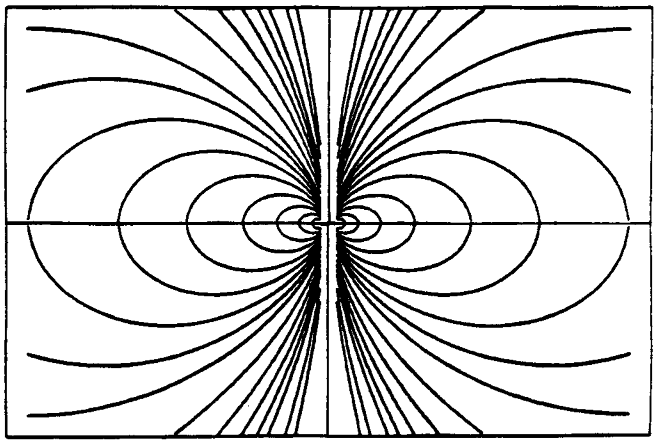

Fig. 1. The primary magnetic field around a coil. (The figure is geometrically accurate.)

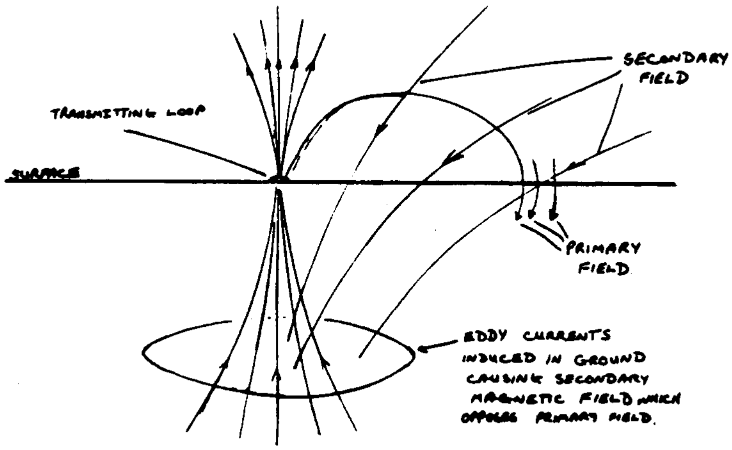

Fig. 2. Showing the primary and secondary magnetic fields arising from a loop on the earth's surface.

The proposed method depends upon using two receiver-antenna orientations, and measuring the ratio of the signal strength. This eliminates calibration of the transmitter, and if the receiver output is linear with input signal, eliminates receiver calibration too.

The proposed procedure is as follows:

1) Set-up the transmitter loop with its plane exactly horizontal on the surface of the ground above the point of interest.

2) Set-up the receiver loop at a measured distance from the transmitter equal to the estimated depth of caves in the area. The loop should be set with its plane exactly horizontal, at the same elevation as the transmitter.

3) Measure the signal strength (volts) with the transmitter off, V(H-background), and transmitting continuous tone, V(H).

4) Rotate the receiver loop so the axis of the loop is horizontal and pointing directly at the transmitting loop.

5) Measure the signal strength (volts) with the transmitter off V(V-background), and transmitting continuous tone, V(V).

6) Calculate (V(V) - V(V-background)) / (V(H) - V(H-background)) and use Graph 1 or 2 to lookup directly the value of the conductivity.

For those people using other values of frequency or inter-loop distance than given in the graphs, I have tabulated the Voltage Ratio against "Numerical Distance" and it will be necessary to calculate the conductivity from the formula given at the end of the table.

I would strongly recommend when doing a traverse along a surface line, that readings be taken with the two antennas aligned with the traverse direction <u>and</u> with the two antennas at right angles to the traverse direction. The reason for this is that I feel limestone terrain will exhibit different conductivity in different horizontal directions (anisotropy). I have experienced directional effects with my cave radio that I cannot explain except by anisotropic conductivity of the ground (See Speleonics 9, page 8).

This observation applies equally to conductivity surveys done by current-injection methods.

Further Work. Obviously there are a lot of practical things which could be tried to see how such an EM system would work. There is however one major theoretical contribution which would be very useful if there is a person out there who has a computer and the necessary knowledge and skill.

The interpretation of the conductivity estimates is very primitive, simply assignment of a "bulk value" to a point in the ground halfway between the loops at a depth equal to their separation.

It seems to me it should be possible to construct a numeric model so that the effect of various sub-surface conditions could be tested. Chambers, joints, bedding-planes, and tubes would all affect the apparent conductivity measured from the surface in different ways. Such a model would also give an estimate of the sensitivity of the method, that is the smallest feature which might be detected under given conditions.

It would certainly enhance the interpretation of conductivity data.

Table 1. Numerical Distance v. Voltage Ratio

Numerical Dist.	Voltage Ratio	Numerical Dist.	Voltage Ratio
0.0	0.0	2.4	0.591
0.2	0.0159	2.6	0.647
0.4	0.0404	2.8	0.704
0.6	0.0872	3.0	0.771
0.8	0.151	3.2	0.819
1.0	0.211	3.4	0.866
1.2	0.269	3.6	0.912
1.4	0.326	3.8	0.963
1.6	0.383	4.0	1.013
1.8	0.437	4.2	1.067
2.0	0.483	4.4	1.127
2.2	0.533	4.6	1.189

Conductivity (mho/m) =
$(ND/d)^2 \cdot (1/f) \cdot 1.27 \times 10^5$

where ND = Numerical Distance
d = distance between loops (metres)
f = frequency (Hz)

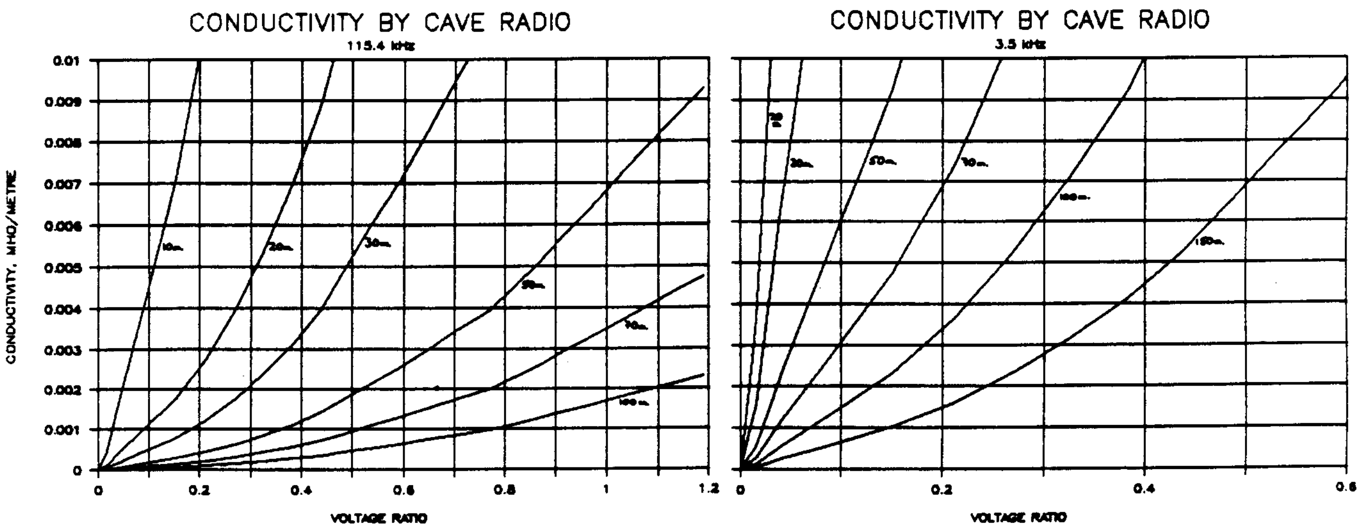

Fig. 3. The distance is the inter-loop distance. Voltage ratio is the ratio of measurements made with the antenna plane vertical, axis on a radial from transmitter, over those made with the antenna plane horizontal.

SCIENTIFIC CAVE LOCATION

by Phil Ingham *

Since early trials proved that earth resistivity methods are of great use in locating underground cavities within limestone masses, the method has been used with considerable success. Whilst there are numerous variations to the equipment layout used to measure resistivity, they all use the principle of a current (I) being introduced into the ground through electrodes, and the potential difference (V) between two points being measured with a second pair of electrodes.

The current is usually generated by batteries in portable equipment, although some generator sets are available. Normally the current used is alternating (AC), and this removes unwanted polarisation effects around the electrodes. If direct current is used, then the polarisation effects have to be countered, by placing the electrodes in porous pots filled with copper sulphate solution. An alternate method involves the use of a high-impedance circuit and compensatory network.

APPARENT RESISTIVITY

If a current is introduced into the ground through a pair of spaced electrodes and the potential v across an area between them is measured, (fig 1), then the resistance can be worked out. The relationship between voltage, current and resistance is defined by Ohm's law. This states that $V = IR$.

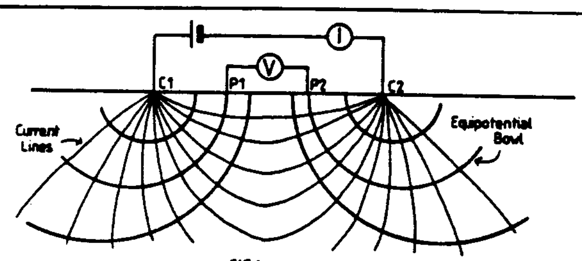

FIG 1

If we consider a point electrode on the surface of a homogenous earth, extending down for an infinite distance and having a resistivity p, by then describing a shell around it of radius r and thickness dr, we can say that the current passing through the electrode into the earth is I, the potential difference across this shell will be

$$V = Ip\ dr/2\ r^2 .$$

By integration, we obtain the potential, at a distance r, from the point, as

$$V(r) = Ip/2 \times 1/r .$$

If C1 and C2 are the current electrodes and P1, P2 are the potential electrodes and V is the potential difference between the electrodes, then it follows that

$$p = 2 \times V/IG$$

where G = 1/C1P1 1/C1P1 1/C2P2 1/C2P2.

In actual use, P will vary when the electrode geometry is altered or when they are moved keeping the same configuration. That means the actual resistance will not be directly proportional to G as on a homogenous earth. The value of p obtained on substituting the measured R and the appropriate value for G, is called the Apparent Resistivity of the earth. This is a formal, rather artificial concept and does not represent the general or average resistivity of the earth. To assess this figure properly, the type of configuration must be taken into account. The apparent resistivity is measured in either ohm metres, or ohm centimetres. (Ωm, Ω cm)

ELECTRODE ARRAYS

There are three main arrangement of electrodes, the Wenner array, the Schlumberger array and the Single Electrode array. Whilst others are in use, it is beyond this article to go into them.

1) The Wenner Configuration is attributed to F. Wenner (1916) who pioneered much of work in the field of resistivity with this array. In the array (fig 2), all the electrode separations [a], are equal so that the apparent resistivity becomes

$$p = 2\pi aR .$$

The separation is roughly equivalent to the depth below the array, to which the resistivity refers. This array is moved along, maintaining the spacing for horizontal profiling, or expanded about the centre point for depth sounding.

2) The Schlumberger array (fig 3) is designed to measure resistivity by measurement of the potential gradient. It uses a pair of potential electrodes which are close-spaced between a pair of wider-spaced current electrodes. The distance is increased in a symmetrical manner for horizontal profiling, whilst for depth profiling, it may be done in a symmetrical manner (fig 3a) or in a non-symmetrical manner (fig 3b), for depth sounding. With large current-electrode spacing, it is necessary to increase the potential-electrode spacing in order to preserve a measurable potential difference across them.

This configuration was used by Palmer (1954, 1959). He plotted the resistance readings against electrode separation, to produce a graph on which high-resistance anomalies caused by cavities could be identified. The depth was found by using the formula

$$\sqrt{\alpha\ a^{o}}$$

where a is the ratio a:b and a^o is the electrode separation at which the anomaly occurred. Tratman (1963) used this method to locate Pen Park Hole.

---

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This article is reprinted from BCRA Cave Radio and Electronics Group vol. 1 no.2 (Winter 1988) pp5-8.

The apparent resistivity of the Schlumberger array when used in the symmetrical form, is given by the formula

$$p = KV/I$$

where $K = \pi a^2/2b$,

whilst for the non-symmetrical form, it becomes, in a much simplified form,

$$p = KV/I$$

where K = $(a^2 - x^2)$PT2PT / $2b(a^2 + x^2)$.

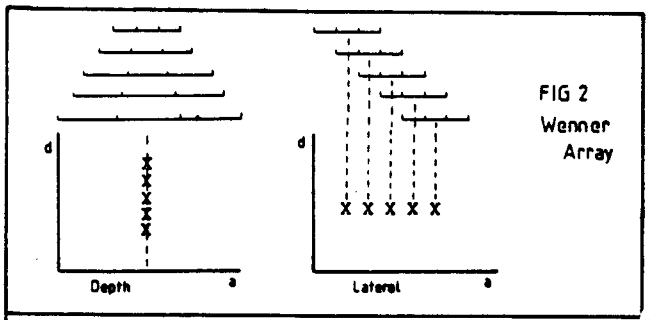

FIG 2 Wenner Array

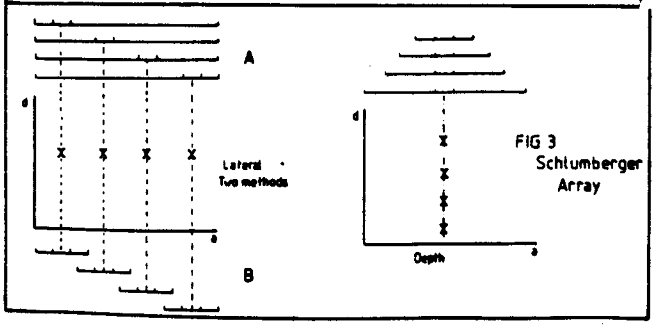

FIG 3 Schlumberger Array

3) The Single Electrode array has been used with some success (Bristow 1966). It works on the assumption that the equipotential surfaces around the single (current) electrode are nearly hemispherical, provided that the second electrode is far enough away to prevent distortion. The two potential electrodes are placed in line with the current electrode, at distances a and b. They then measure the potential drop between two of the equipotential surfaces. The apparent resistivity is described as

$$p = 2\pi ab/a - b.$$

THE CHOICE?

Both the Wenner and Schlumberger methods can be used to give results under most conditions. There are advantages and disadvantages of both. If vertical measurement is all that is required, then the maths involved in the Wenner array are simpler. However, the array suffers from the major disadvantages that a) it must all be moved for each reading, which involves a great deal of labour, and b) it is unable to resolve variations caused by near surface features and deep layers.

The Schlumberger array can, on the other hand, resolve both the near surface and deep features, however, the maths involved in the calculation of the results are far more complex. For horizontal work, the Wenner array is most preferable due to the fact that the graph curves produced are more symmetrical, but the Schlumberger is the more efficient in terms of time and requires far less labour than the Wenner array. It, however, suffers from the fact that horizontal profiles must be backed-up by vertical sounding, which adds to the time that must be spent in the field.

INTERPRETATION

The two sounding methods each give different results. Constant-separation traverses (i.e. the array is moved each time) give a picture of the resistivity at a given depth along the traverse, whilst the expanding method gives a profile down from the electrode point. If the earth was a series of nice homogenous layers, then interpreting the results would be easy. As it is, the layers are uneven and vary greatly in composition. The problem of two- and three-layer earths becomes quite complex; the full solution is outside the scope of this article. However, the basic idea can be seen in fig 4, where two layers are encountered. The usual way of resolving these problems is to refer to standard curves and make a comparison; this way, accurate profiles can be made.

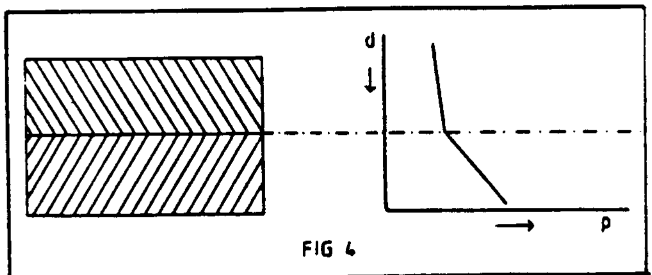

FIG 4

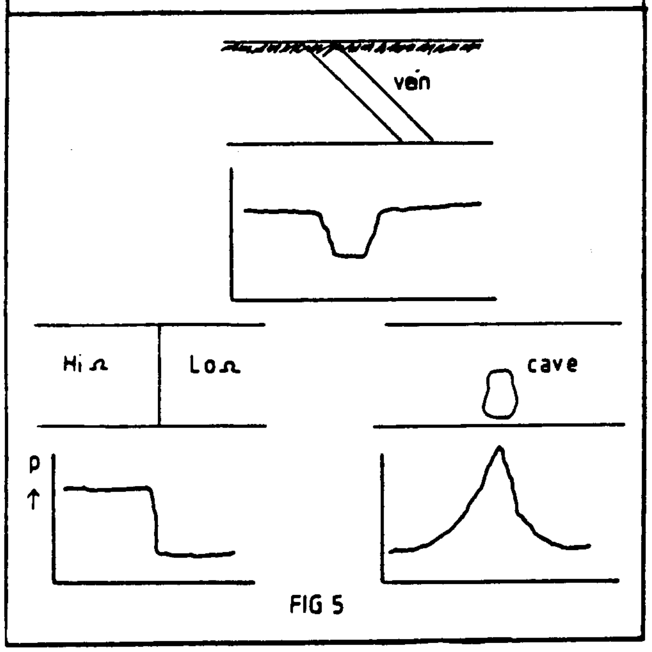

FIG 5

In use for cavity location, the two-layer curve does not present too may problems, so long as the electrode spacing is greater than any overburden. Usually, however, the area will equate to limestone pavement with no or little overburden, so the problem disappears.

Examples of the types of curve to be expected are shown in fig 5. The cavity will, of course, show as an area of infinitely high resistance, whilst mineral veins will usually show high conductivity due to their metal content and thus low resistance. Table 1 gives some typical resistances of various rock types.

TABLE 1: RESISTIVITY OF COMMON ROCKS

Sandstone	1 - 6.4 x 10^7
Limestones	50 - 10^7
Wet limestone	0.6 - 10^3
Marls	3 - 70
Dolomite	3.5 x 10^2 - 5 x 10^3
Lavas	10^2 - 5 x 10^7
Tuffs	2 x 10^3 - 10^5
Alluvium/sand	10 - 80
Conglomerates	2 x 10^3 - 10^4
Wet clays	20

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LETTERS [continued from p. 3]

side, and negative on the exposed (male) side. The device or LOAD connector takes negative on the rubber-covered (female) side, and positive on the naked male pin, which is okay as there is no electricity in the load device (radio, lamp, etc.) when it is disconnected to short out against any metal which the exposed pin might contact.

These molded rubber plugs come in sets of two with red and black wires appropriate for one-each source and load connection (altho you can ignore the wire color if you want; they cannot be connected the wrong way, even in the dark!). The plugs grip each other firmly, unlike the Cinch-Jones type that will fall out with any gentle tug. They are also water and mud resistant, which Cinch-Jones are not. The only inconvenience is that the wires are molded in; if you want to extend them you have to do a solder and heat-shrink splice (or twist-'n-tape in an emergency), but this is no big drawback. Extension cords and multi-outlet "octopus" dividers are made simply, without any bulky chassis boxes involved.

I've used this type of connector for years on all radio equipment, 12-volt soldering irons, spotlights, chargers, etc. I have found many other people who use 12-volt auto accessories also using this connector in their vehicles, and invariably they've figured out how to get the polarity right without referring to any published "standard."

Ron Johnson WA5RON
12700 Silver Creek
Austin, Texas 78727

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This is the missing part of **Dave Johnson**'s letter (SPELEONICS 11):

...I hope someday to build a VLF-LF "communications receiver" and am in the process of collecting ideas on how to implement such an animal. The biggest engineering difficulties I see in such a project are as follows:

1- Getting sufficient resolution and stability. I figure that resolution has to be 1 Hz below 64 kHz, and stability should be comparable (16 ppm). Easy enough to achieve with a good direct synthesizer but those guys are expensive and they eat batteries too. Ten years from now they'll probably be the only way to go, but for now I prefer phase locked loop. Yes, I'm aware of the horrendous attention to detail involved in getting this kind of performance out of a PLL, while also achieving low phase noise and reasonable lock time.
2- Tuning the RF stages. To span (shall we say) 3 to 300 kHz can't be achieved just by switching taps on a coil. The problem of tuning is complicated by the need to provide notches at 100 kHz (LORAN C) and perhaps other frequencies in order to maintain mixer linearity without having to crank gain down too much. Also, if the system is based on direct conversion, the front end will demodulate the harmonics too.
3- Some people want to listen wideband, some want to listen narrowband, some want to demodulate data using standard RTTY format, some want MAX 10-baud protocol, some want to extract standard time from WWVB's signal, etc. It ain't like 550-1650 kHz where everybody wants to listen to voice and music AM and nobody needs anything else. How many different reception modes should be provided? If you satisfy everybody, the machine has to sell for $10,000 and takes two people to lift it.

Sometimes I figure direct conversion is the best way to go, and sometimes I figure upconversion followed by direct conversion is the best way. Both approaches have merit. Upconversion costs more, but it relaxes the design of the RF stages so overall it's probably cheaper, esp. if you really do intend to cover 2 decades of frequency.

Dave Johnson
713 Texas Ave.
Los Banos, CA 93635

CAPACITIES OF PRIMARY CELLS

Part 1:

From computer newsgroup rec.ham-radio, 25 June 1988:

Subj: Capacity of 6V lantern batteries

John Opalkos, N7KBT writes:

> What is the mAH capacity of a... 6-volt lantern
> battery, preferably alkaline? I want to put
> battery backup on a device that draws 750 mA
> and I need to know how long the battery will
> last.

Leclanchè cells (carbon-zinc) do not have "simple" ampere-hour ratings; the effective rating depends upon the load current, whether the load current is steady or intermittent, and the actual time periods involved. In addition, one must also define an "end voltage" - which is MUCH more variable with Leclanchècells than with any other type of cell.

However, to give some ballpark figures:

(1) An Eveready(tm) 610S (2.5 x 2.5 inch lantern battery) with a 500 mA continuous load will provide roughly 2 ampere-hours of energy to an end voltage of 4.0 volts. The recommended maximum discharge current for this battery is 250 mA.

(2) An Eveready 731, which is a 3 x 5.5 inch [7.5 x 12.6 cm] lantern battery, with a 500 mA continuous load will provide roughly 5 ampere-hours of energy to an end voltage of 4.0 volts. The recommended maximum discharge current for this battery is 500 mA.

> Or, should I just get a deep-discharge lead-acid
> battery and a trickle charger?

In this day and age, Leclanchè cells are really outdated for standby power use. I would suggest that you use a gel-cell and trickle charger. You should be able to buy a 6-volt 4-ampere hour gel-cell for not much more than $ 10.00 at retail prices. If you shop around in surplus stores, you should be able to do much better.

Alkaline F-cells (the size used in lantern batteries), if you can find them, should contain 18-20 ampere hours. Alkaline D-cells contain 9-10 ampere hours, depending on manufacturer and age. Four of them and are a smaller and more cost-effective alternative to carbon-zinc lantern batteries.

<> **Larry Lippman** @ Recognition Research Corp.,
<> Clarence, New York.
--

ANSI battery-size designations (as of 1972) are: O, N, AAA, R, AA, A, B, C, D, E, F, G, No.6, in order of increasing volume. O, R, A, B and E are used only as parts of batteries, and are no longer sold as individual cells.

<> Norm (strong@tc.fluke.com) 9 Feb. 1989

Part 2:

In answer to our request for battery-capacity information [SPELEONICS 9, p.11], **Nick Williams** of the **BCRA Cave Radio and Electronics Group** sent pages from the catalog of STC Electronic Services (a British electronic-components supplier), listing capacities of Duracell(tm) alkaline cells and batteries. This information seems difficult to obtain in the U.S.

As discussed in the first half of this article, primary-cell capacity depends upon many variables. Testing methods recommended by the U.S. National Bureau of Standards are described in Eveready Battery Applications Engineering Data published by Union Carbide Corporation.

Several sources rate alkaline D-cell capacity at 9-10 Amp-hrs. Manufacturers have recently claimed process improvements giving 30% more life. Test parameters for the data in the table below are not known. The relative capacities which we have calculated should be valid within any chemical system and manufacturer.

Duracell part no.	Size	Volts	Capacity mA-hr	Capacity W-hr	mA-hr rel. to D-cell	See note
MN1300	D	1.5	15000	22.5	1.00	
MN1400	C	1.5	7000	10.5	0.47	
MN1203		4.5	4400	19.8	0.30	1
MN1500	AA	1.5	2250	3.4	0.15	
MN2400	AAA	1.5	800	1.2	0.05	
MN9100	N	1.5	650	1.0	0.04	
MN1604		9.0	500	4.5	0.03	2
Lantern batteries:						
PC908	F	6	20000	120	1.33	3
PC915	F	6	20000	120		
PC918	F	6	40000	240	2.67	4
PC926	F	12	20000	240		

Notes:
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1. MN1203 is the 3-cell battery used in Petzl(tm) headlamps from France. The cells are larger than AA, smaller than C; they are not commonly available in the U.S. An adapter for the Petzl lamp holds three AA-cells which, as shown above, have only about half as much capacity.

2. MN1604 is a 9-volt "transistor" battery with snap connectors. Unlike similar batteries which are stacks of flat rectangular cells, MN1604 contains six cylindrical cells smaller than AAA size, connected by spot-welded stainless-steel straps. The indvidually-insulated cells can be separated for special applications.

3. PC908 has spring terminals, PC915 has screw terminals.

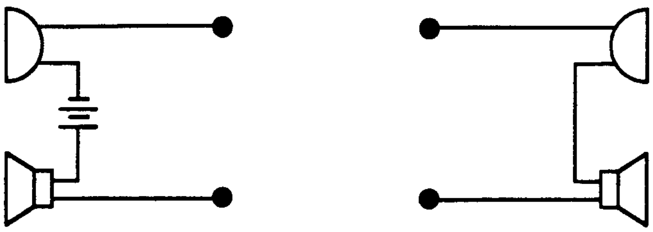
4. PC918 and PC926 are double-width lantern batteries. PC918 has eight F-cells in seriesed parallel pairs, PC926 is 8 cells in series.

SUMMARY OF THE CAVE-RESCUE TELEPHONE PROJECT

(Condensed from Project Summary #1 of the Wasatch Grotto of the NSS)

John Halleck *

Our original cave-rescue telephones (called Murphy Phones) were standard telephone handsets with their earphones and microphones wired in series, both sets in series with a battery on the surface. These cost about $7.50 each to produce; most of the cost is in making them "caveproof."



Mark I

This simple but reliable arrangement solved the immediate problem with simplicity, durability and low cost, but was not compatible with the standard military-surplus field phones that others might bring to a rescue.

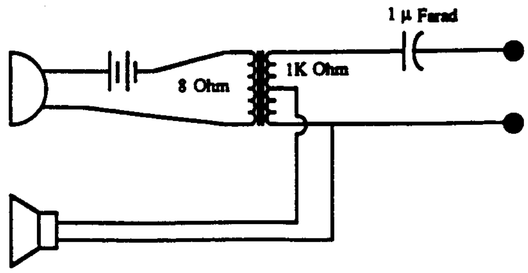
The main advantage is more subtle: When talking into a phone, you can hear your own voice in the earpiece. Telephone people call this "sidetone." The easiest way to test for it by blowing into the mouthpiece. If you can hear yourself blowing, you "have sidetone." Sidetone was to become the most important element of the phone testing and design.

The original series-circuit design failed whenever the line was broken. When phones went dead, everyone knew there was a problem, and immediately sought to repair it. Even local children recruited to test phones were able to debug this simple circuit.

Disadvantages were that the surface phone, having a battery, was different than the underground phones. Confused practices with "Everybody grab a phone and go set up" tended to result in either no surface phone in the net, or several. Such problems were always quickly cleared in such a simple system.

While the Murphy phones are a design that any rescue group can produce cheaply, the incompatibility with standard field telephones remains a significant problem for any group that participates in rescues with other groups.

Our first field-phone-compatible version was a design suggested by Frank Reid:



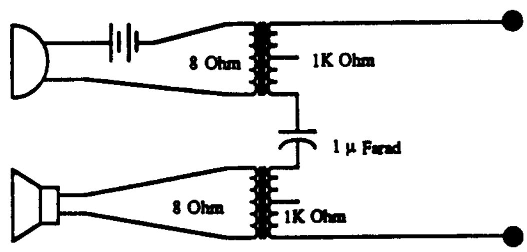
Mark II A

The capacitor keeps any DC on the line from saturating the transformer, and presents a high impedance to the high-voltage 18Hz ringing signal that field phones generate. The transformer acts as an "autotransformer" to impedance-match the line and the earphone. This version receives quite well but does not transmit to the line as well as later models.

The Mark II-A version solved compatibility problems but had undesirable sidetone properties: When the line connection begins to fail, more current is shunted through the earpiece and is unavailable for the line. The worse the connection, the louder the sidetone-- The user sounds louder to himself, and talks softer to compensate.

Such behavior made line trouble less noticeable, thus delaying repairs. Field tests proved that we needed a field-phone-compatible unit having the sidetone characteristics of the original Murphy phone, i.e., no connection = no sidetone.

The Mark II B addressed the problem with a second transformer. We reasoned that if the direct-connection phone worked well, then stepping the signal up and down by the same amount would also work well.



Mark II B

The Mark II B transmitted well but received poorly. It restored desirable sidetone behavior, but sounded faint because of signal losses in the transformers.

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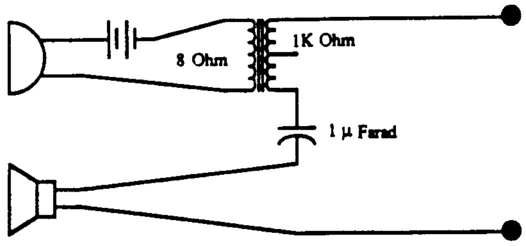
* P.O. Box 8489
Salt Lake City, Utah 84018-0488

We tried putting all the line power into the earphone:

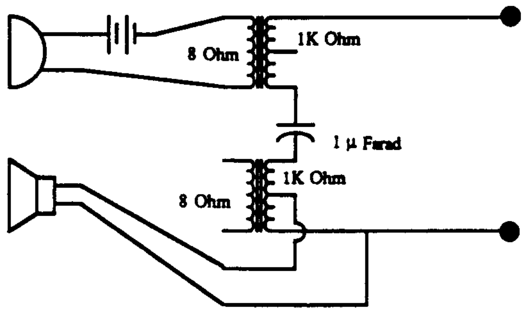


Mark II C

This Mark II C version transmits badly and receives worse due to impedance mismatch. We decided to learn more theory and try again.

FINALLY...

We have settled upon the Mark II D design. It transmits and receives well and is as easy to debug as the original Murphy phones. It is compatible with standard field telephones, and can be attached in parallel with a network of Mark I phones. Each phone costs less than $15 to produce. For total compatibility with Mark I phones, attach a 1K resistor across the binding posts of the Mark II D's.



Mark II D

All Mark II designs have an important difference from the Mark I telephones: They can work through a single-wire line and "ground loop." (More on this later.)

Mark II D phones' only problem is that they have no bells or ring-generators. This has proved a minor problem within our group, but caused some complaints at the NCRC annual cave-rescue training seminar. Of several solutions to the ringer problem, none yet produced are compatible with standard field telephones while being simple, rugged and cheap.

USING PHONES IN "ONE WIRE" MODE

We have tested "One Wire" mode extensively with our current telephone model. This arrangement uses a single wire between telephones, with the other wire from each phone connected to earth ground. This mode is also called "ground loop" mode. In all trials thusfar it has worked well, transmitting over 600 feet into a cave in one attempt, and over 1500 feet in another on the surface.

The most important consideration seems to be good contact at the ground point, regardless of the state of the earth between the points. An inch of mud at both ends makes a big difference.

We have found that the best approach is either to stick the wires into mud, or to pour a little water on the ground and make a mudhole for the wire. An inch of bare wire in mud is better than several feet of wire in dry dirt. Salty water works better, but seldom enough better to be worthwhile.

We have found no place where "ground loop" did not work, but we are not yet confident enough to establish this as our default method.

NETWORKS OF PHONES

Mark-I phones worked well with more than two phones in series (as expected) and in parallel (unexpected). We needed another 1.5 volt cell in series to drive two underground phones in series.

The final model works well when added in parallel to networks of the original Murphy phones, or to networks of standard field telephones. We have had as many as seven phones in a network, including a mixture of original (in 2-wire mode) and Mark II versions (in both one and two-wire modes).

QUICK IMPROVISED CAVE-RESCUE TELEPHONES

What is the cheapest method for having cave communications available when needed This model is equivalent to the original Mark I design and shares both its incompatibility with standard field phones and its inability to run in one-wire mode.

Prepare two cords in advance, and beg, borrow or otherwise obtain two handsets at the time of the rescue.

Start with two telephone handsets with cords attached. Cut off the "modular" connectors on the outer ends of the cords.

Inside the handset cord are four insulated wires:

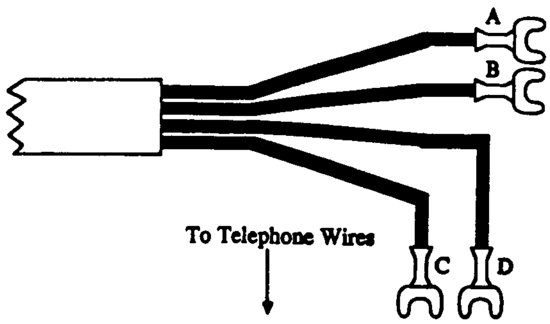
The inner pair of wires go to the earphone, the two outside wires connect to the microphone.

Each of these "wires" has something resembling tinfoil inside. This "tinsel wire" is, at best, hard to work with, and very hard to solder.

The easiest way to terminate the wire is with crimp connectors (available at Radio Shack and automotive-parts stores).

Bend the wire over, slip a crimp connector over it, crimp it on. The resulting connection is reliable and durable.

Strip 10 cm (3 or 4 inches) of outer sheath from the cord end. Put a terminal on each wire.



For both surface and underground phones, connectors "C" and "D" go to the telephone lines.

For the underground phones, connect "A" and "B" together.

For the surface phone, connect "A" to one side of the battery, and "B" to the other side.

You now have cheap, workable phones which will run for weeks on a single 1.5 volt cell. If using more than one underground phone, you may need to add an additional 1.5 volt cell for each underground phone. The easiest way to make the connections is with wood screws in a block of wood, holding the connections under them.

Since these connections do not affect the handset itself, you need only the modified handset cords in the rescue cache.

Parts used in the phones

Microphone: This is the standard carbon microphone found in the mouthpiece of Bell System (Western Electric) telephones.

Receiver: This is the standard 1000-ohm telephone earphone. It comes with a metal oxide varistor between the two terminals; leave that in place.

Binding posts: I use two Radio Shack 274-661 (supplied in a package of four). Smaller types are available; the large terminals are worthwhile for extra durability.

Transformers: Radio Shack 273-1380. Primary: 1000 ohms center-tapped; secondary 8 ohms.

Capacitor: 1 microfarad nonelectrolytic; 100 volts or more, e.g., Radio Shack 272-1055.

Battery holder: Radio Shack 270-398 (holds two AAA-cells). It has been argued that using AA cells instead would make it easier to find batteries. Radio Shack's AA holders (270-382) have proven unworkable; they break when exposed to extreme heat or cold with batteries installed. They do hold up if the batteries are stored separately.

Internal wires: I use 20-gauge (0.812 mm dia.) insulated stranded wire.

Electrical tape: Needed on all connections; there have been problems with nuts coming loose on the inside, causing intermittent shorts.

BUILDING RUGGED PHONES

1. Use the older Western Electric (AT&T) handsets (Model 500). The new electronic types are much less durable. Test used handsets and inspect their insides before buying;

2. Dismantle the handsets. You should see screw-on mouthpiece and earpiece caps, a receiver (with green and white [or yellow] wires), a carbon microphone, and a plastic base for the mike (with red and black wires), and a modular jack attached to the base.

3. Remove the modular jack, grab each of the contact wires and bend them out straight in front of the jack. You should now be able to remove the wires from the jack. This will leave all wires accessible from the mouthpiece; they will all have copper wire pins on the ends.

4. Break-off the tabs that held the modular jack in place (You will need the space to install the line binding posts at the bottom of the phone.)

5. Drill holes for the binding posts, and install them. It is best to drill the holes slightly too small, since screwing-in the binding posts seals them watertight. Don't place them so that they prevent reinserting the receiver and microphone.

7. Seal the hole at the end of the phone (that formerly held the connector) with silicone rubber. DO NOT get the rubber on unprotected metal. (It is corrosive during the curing process.) Ordinary candle wax brushed on the metal will protect it from the rubber if desired. Cover the hole from both inside and outside so that the seal can't pop out in either direction. Let the glue cure overnight (Leaving the handset disassembled aids curing.)

8. When putting the earphone back in, cover it with a plastic bag and carefully screw the earpiece cap over the plastic. Cut off the excess.

9. Replace the microphone base and microphone, cover with plastic between the cap's screw threads as above.

PRECAUTIONS

1. Do not overtighten the binding posts when attaching the phone line. Finger tight only! (Overtightening may twist the binding posts on the body and short things inside.)

2. After attaching the wires, wrap them around the phone a few times, and tape or tie a strain-relief loop to protect the binding posts and their connections in case the wire is jerked.

PHOTOS OF LUMINESCENT CAVE MINERALS WANTED

[Received 31 January 1989]

Union International de Spèlèologie

To All the Members of the Commission

Bologna May 10, 1988

Object: Request of co-operation for an International program on the luminescence of cave minerals

Dear Colleagues,

According with the resolution taken during our informal reunions held in Bulgaria and USSR last year, I am writing you to ask for help in order to improve our knowledge in a field (that of luminescence of cave minerals) till now neglected or, at least, not sufficiently developed.

The aim of this program is to print an "International Atlas on cave luminescence" in the near future.

Our colleague Y. Shopov from Sofia will be the leader of this program and will perform all the laboratory analyses.

What is asked you is simply to take slides following the enclosed instructions and to send them directly to Shopov.

In the "Atlas" all the material will be clearly referred to their authors.

I hope that all of you will make the maximum possible effort to help our Commission to reach this goal.

Please send this information to your colleagues or friends, who may be interested in such kind of activity.

Thank you in advance,

The President of the Commission
Prof. Paolo Forti

--

U.I.S. COMMISSION ON PHYSICAL-CHEMISTRY AND HYDROGEOLOGY OF KARST INTERNATIONAL PROGRAM FOR THE STUDY OF THE LUMINESCENCE SPECTRA OF CAVE MINERALS

The aim of the program is the determination of the colours, the spectra and the elements causing speleothem luminescence; at the end of the research an atlas on the luminescence of cave minerals of the world will be printed.

The program is divided into 3 stages;

I - The collecting of luminescence slides
II - Their spectrophotometry by Shopov's method
III - The edition of the atlas on the luminescence of cave minerals

All cavers interested in this program are welcome to participate in the first stage, following the given instruction to obtain phosphorescence slides.

The second stage will be performed in Shopov's laboratory at the university of Sofia.

Speleothems growing in caves close to ore bodies, or in hydrothermal environments, as well as in lava tubes, normally are the more interesting ones from the luminescence point of view.

INSTRUCTIONS FOR TAKING SLIDES OF LUMINESCENT CAVE MINERALS

1) A reflex camera with "M" or "FP" synchronizer for magnesium flash and curtain shutter is necessary to obtain phosphorescence slides. Some cameras like EXACTA, ZENIT-B and other old cameras have a built-in "M" synchronizer with a 0.003 - 0.01 second delay. Modern cameras need an additional shutter delayer.

2) Electronic flash(es) with leading number higher than 25 are necessary for the excitation of phosphorescence. The power of flashes must be as high as possible. Several synchronized flashes may be used to increase illumination.

3) Only colour-slide daylight films with a speed as high as possible (400-1000 ASA) are to be used.

HOW TO TAKE THE SLIDES

1. Put the camera on a tripod.
2. Take a normal slide of the sample: Macrophoto is better.
3. Put shutter rate in "B".
4. Connect flash(es) with synchronization jack "M" ("FP").
5. Put the flash(ES) as close as possible to the speleothem, but take care that it will be fully lighted.
6. Open the diaphragm completely.
7. Switch all lights off.
8. Make a test shot with closed eyes; open them immediately after the shot. Correct the position of flashes if necessary to obtain higher phosphorescence.
9. Keep the camera open until full extinction of the emitted light is reached.
10. Leave 3-4 cm of unexposed film (to obtain a "black" sample).
11. For each speleothem prepare a "normal" slide and a well-exposed phosphorescence slide (overexposed slides are not useful for spectral processing).
12. Make a list of the slides (see the accompanying form) and mail them together with the "black" sample to:

Y. Y. Shopov, Bulgaria 1408, Sofia, Dimitar Manov 74

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FORM TO BE FULFILLED FOR EACH SLIDE

1. Photographer: (name and address)
2. Type of camera
3. Used films and speeds
4. Location of sample; country, cave
5. Rock in which the cave is developed
6. Kind of cave mineralization: a) normal speleothem; b) guanogenic; c) volcanic; d) hydrothermal; e) metamorphic
7. Temperature in the cave
8. Mineral composition of each sample (if known)
9. Type of speleothem for each sample
10. Possible additional data