



[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!

CONTENTS

THERE IS NO NOBEL PRIZE FOR SPELEOLOGY
[cover story]

Editorial 1

NEWS & ANNOUNCEMENTS -
Informal Spring Meetings
Regular publisher unavailable 1
"Radio Pit" opened
Cave rescue on network TV
Super LEDs to be available at NSS Convention.
Call for papers 3

AUSTRALIAN RESCUE USES CAVE RADIO
Ron Allum 2

LETTERS -
Dave Ursin, Ron Johnson 3
Dave Johnson 8

Magnetic Moments #9:
GROUND CONDUCTIVITY BY ELECTRO-MAGNETIC METHODS
Ian Drummond 4

SCIENTIFIC CAVE LOCATION [reprint]
Phil Ingham 6

CAPACITIES OF PRIMARY CELLS
[collected reprints] 9

SUMMARY OF THE CAVE-RESCUE TELEPHONE PROJECT
John Halleck 10

PHOTOS OF LUMINESCENT CAVE MINERALS WANTED 13

RESOURCES: ULTRAVIOLET LAMPS FOR MINERALOGY ... 14

JAPANESE CAVE-RADIO USED IN WORLD WAR II 15

REVIEWS -
Bat detector, Field telephones,
BCRA CREG v.1 no.2 15

Electronic Bat-Feeder [cartoon]
artist unknown 14

Art by Jay Jordan 15

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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.

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

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 HAM-VENTION** (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.

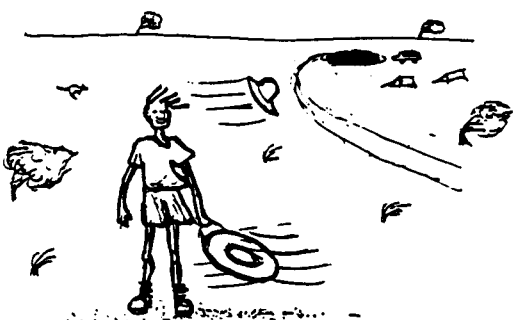
[Continued p. 3]

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 especially when you need it most.

Ron Allum
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AUSTRALIA



Strong winds prevent R.D.F. reception.

Erroneous rumors preceding 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 Cocklebidy, 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.

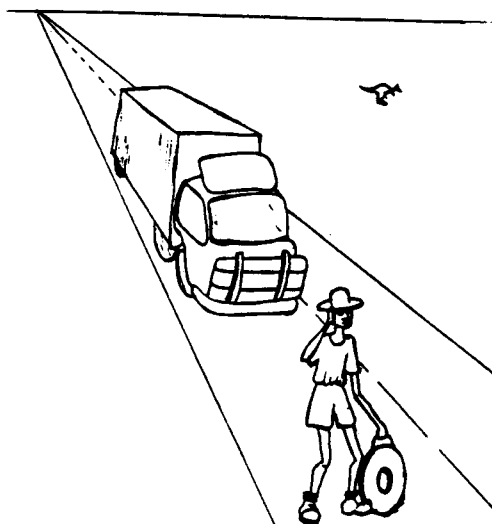
The documentary crew includes people who in 1983 broke the world record in cave diving distance in the same system of caves...

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.

NEWS AND ANNOUNCEMENTS [continued from p. 1]

LETTERS

"RADIO PIT" OPENED. Doug Medville's article in DC Speleograph (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 The Canadian Caver, Spring 1988.
--

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

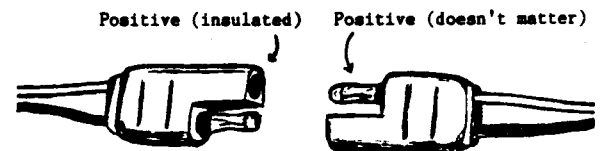
Dave Ursin
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CAVE RESCUE ON NETWORK TV. Indiana cavers re-enacted a 1985 cave rescue for CBS Television, to be aired sometime in May as part of a 3-part series entitled "911 Rescue." The cave segment will be 10-15 minutes long.
--

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.



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]

SUPER LEDs TO BE AVAILABLE AT NSS CONVENTION
John Malleck 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.
--

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 NSS Bulletin. 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 NSS News).

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 about 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.

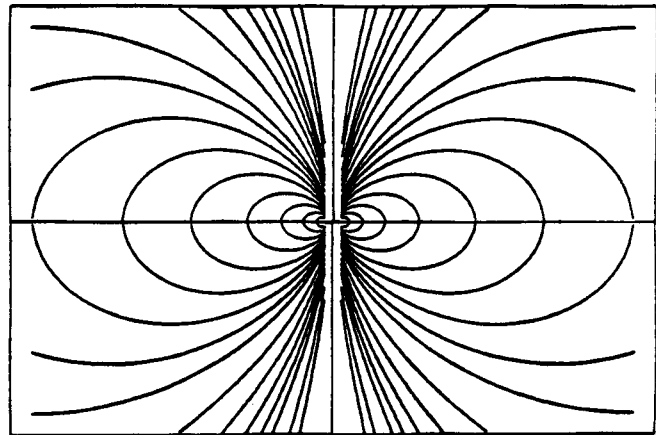


Fig. 1. The primary magnetic field around a coil. (The figure is geometrically accurate.)

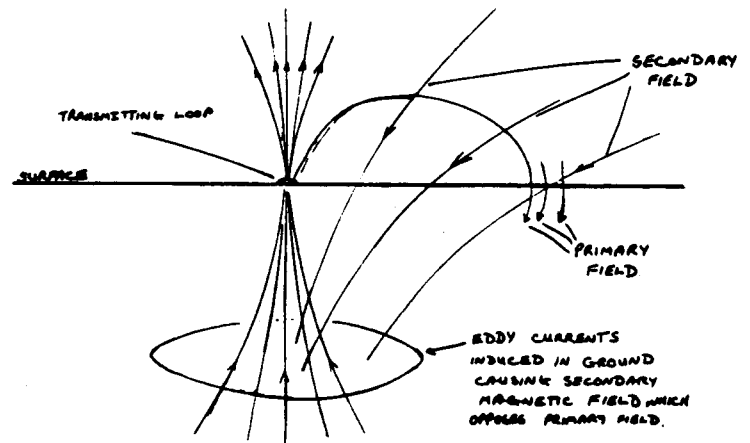


Fig. 2. Showing the primary and secondary magnetic fields arising from a loop on the earth's surface.

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, $V(H\text{-background})$, 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 $V(V\text{-background})$, and transmitting continuous tone, $V(V)$.
- 6) Calculate $(V(V) - V(V\text{-background})) / (V(H) - V(H\text{-background}))$ 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 and 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

$$\text{Conductivity (mho/m)} = \frac{(\text{ND}/d)^2 \cdot (1/f) \cdot 1.27 \times 10^5}{\text{Voltage Ratio}}$$

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

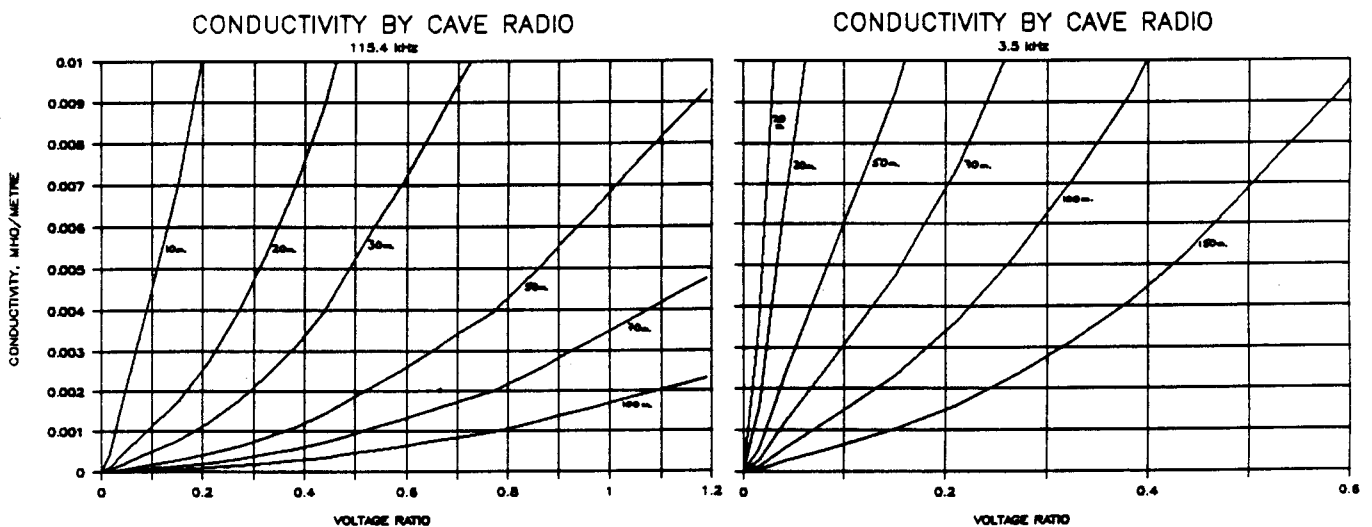


Fig. 3. The distance is the inter-loop distance. Voltage ratio is the ratio of measurements made with the antenna plane vertical, axis on a radial from transmitter, over those made with the antenna plane horizontal.

SCIENTIFIC CAVE LOCATION

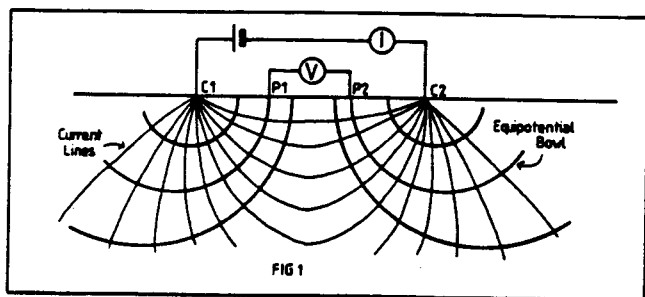
by Phil Ingham *

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 $V = IR$.



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

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

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 $G = 1/C1P1 \, 1/C1P2 \, 1/C2P1 \, 1/C2P2$.

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. ($\Omega m, \Omega cm$)

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

$$\sqrt{a \, a^0}$$

where a is the ratio $a:b$ and a^0 is the electrode separation at which the anomaly occurred. Tratman (1963) used this method to locate Pen Park Hole.

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