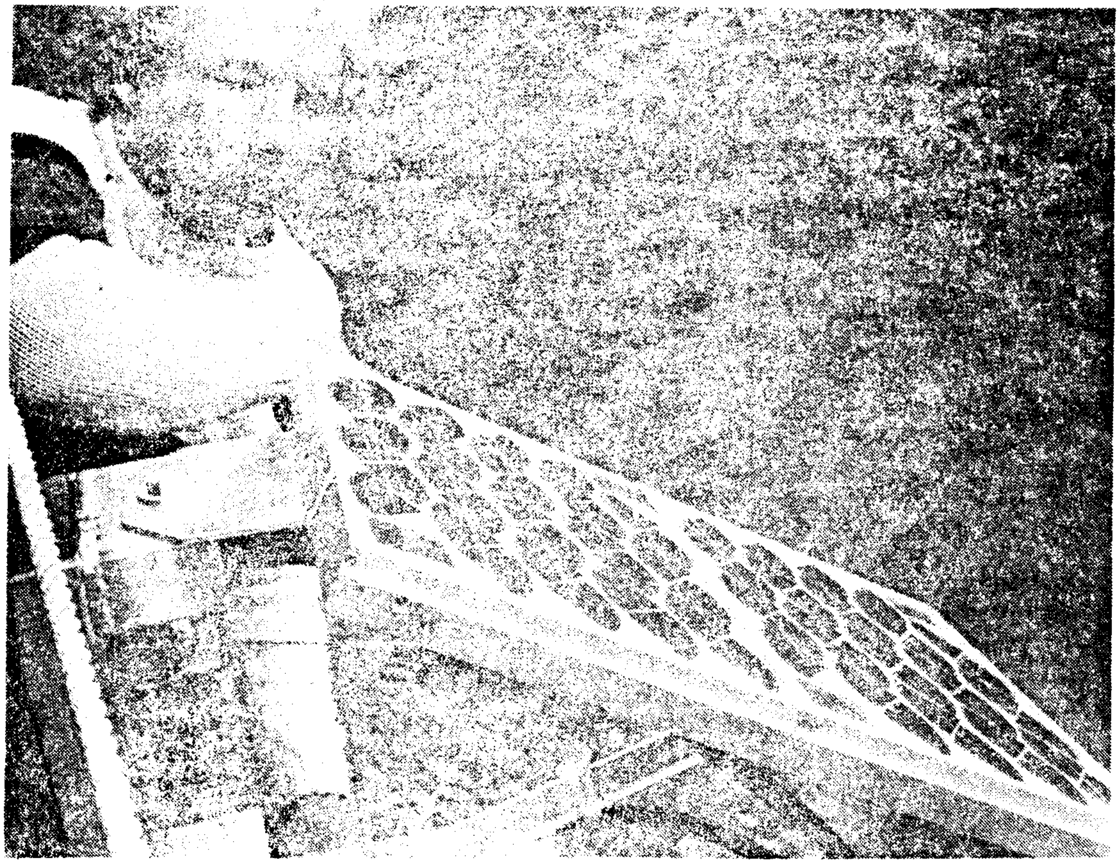
speleonics 7

SPRING 1987

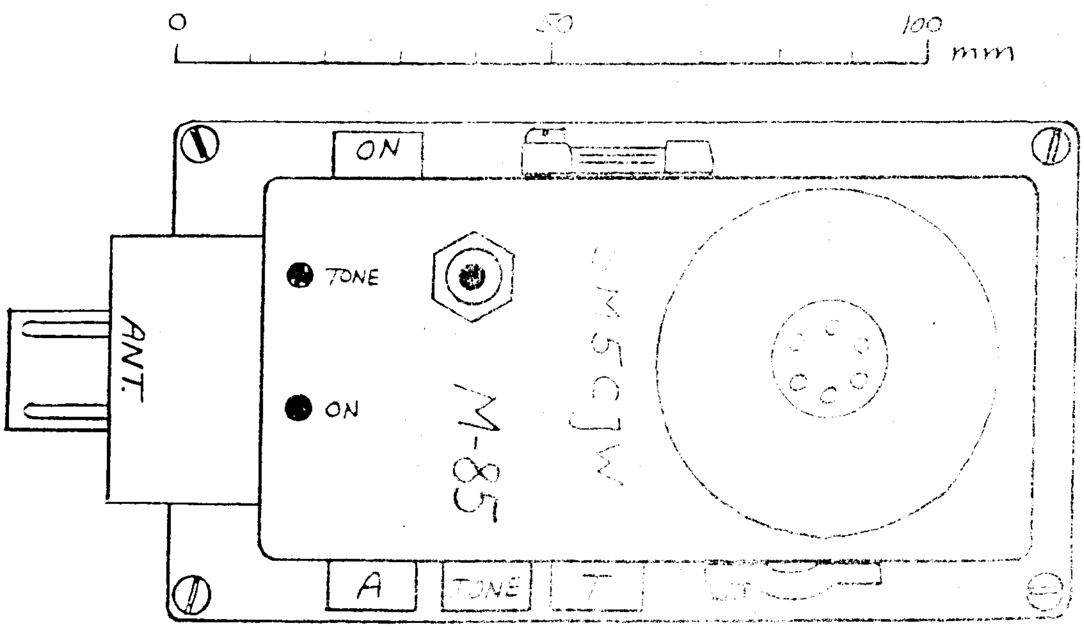
"BETTER CAVING THROUGH ELECTRICAL STUFF"

volume II number 3



SOLAR POWER AT A CAVE RESEARCH FIELD STATION

page 4



DOUBLE-SIDEBAND VOICE CAVE RADIO TRANSCEIVER FROM SWEDEN

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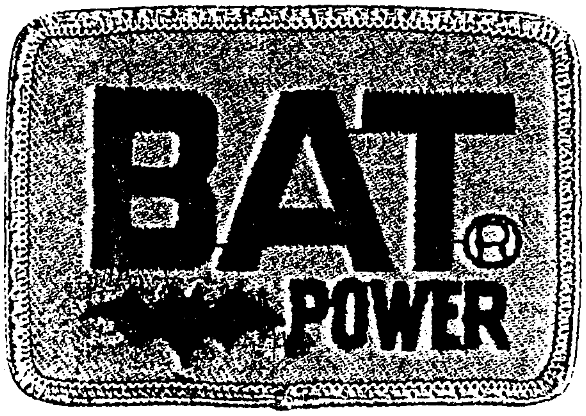

Modified "CAT DIESEL POWER" patch

(originator unknown)

ANNOUNCEMENTS

Information Wanted: CAVEMOBILE ELECTRONICS

Many cavers spend more time travelling to and from caves than they spend underground. If you have unique ways for making this most dangerous phase of caving safer or more pleasant, please write an article or send a letter to the editor. We'd like to hear about radios, sound systems, lights, radar detectors, navigation, heaters, coolers, auxiliary power systems, anti-theft systems, also ingenious nonelectric devices or strategies (tools, safety equipment, ways to hide valuables, etc.).

ERRATUM

We apologize for omitting **Mexico** from the list of countries represented by our foreign members [SPELEONICS 6].

COVER

(Top): **Dave Zoldoske** inspects the photovoltaic array that powers radio, cave telephone, and instrumentation at the Cave Research Foundation's study site at Lilburn Cave in Kings Canyon National Park, California. The installation is 130 feet up in a fir tree. [See article by **Howard Hurtt**]

(Bottom:) Swedish caver **Bo Lenander's** 32-kHz double-sideband cave radio (top view, actual size). The 6.4cm-thick unit contains the battery. Complete plans in this issue!

LETTERS

Dear Frank, 87-01-20

...Julian Coward and myself are about to make some more ASS Cave Radios [SPELEONICS 5], so we will be getting a batch of PC boards made-up. We will sell extra sets at cost, so if you know of anyone who is interested, tell them to write.

I tested my "giant" antennas last weekend. Using 10 watts PEP, we were able to get two-way speech between two points on the surface, one 480 m above the other with 1100 m separating the two sites. The 13 m square antennas are not moveable, of course, so there was no rotation to try and get an optimum orientation. We just slapped them down and turned on. I am hoping to try them in Castleguard this spring. We can get about 550 m depth at one point in the cave. At this range and frequency we will have lost the classic directional properties of the magnetic field, so the giant antennas are only of use for communication and not for surveying.

Ian Drummond
5619 Dalwood Way NW
Calgary, Alberta
CANADA T3A 1S6

Dear Ian, 28-Jan-87

As you know, I have been interested in the development of reliable and "idiot-proof" cave radio systems for over 20 years, but it is only within the last 10 years that advances in microelectronics have resulted in the availability of small, light-weight and cheap integrated circuits for use in low frequency magnetic induction two-way speech systems.

While working at Lancaster University in the 1970's, I collaborated with... Bob Mackin to design and build a prototype SSB system operating at 102.4 kHz, and generating 10w of transmitter power. We used 12-way ribbon cable, mounted on collapsible X-shaped perspex frames, to give 1m by 1m square loop antennae, for both underground and surface sets. We experimented with this equipment, which we called the SPELEOPHONE, mainly in the Gaping Gill system, and found that the range for both speech and tone... was in excess of 350 feet, except where the surface was covered with an appreciable (10m) thickness of peat bog and glacial drift. This reduced the range significantly, to about 100-150 feet, due to the relatively high conductivity of the boggy ground cover... The other major limitation on range that we found was the occasional very high level of LRF signal we encountered with the surface set, particularly when operating on top of the limestone benches in certain south-westerly facing Dales. We never positively identified the source of the interference, but assumed it to be some sort of aircraft navigation beacon system, or VLF radar. The curious feature was the way the shape of the valley appeared to focus the interference, almost as if the valley was acting as half a horn antenna!

In the late 70's, Bob Mackin and I parted company... He was grant aided by Yorkshire Television to produce a version of the Speleophone for use by cave divers, to enable Geoff Yeadon and Oliver Statham to talk to the surface, and their position followed on the surface, while they completed the Kingsdale Master Cave - Keld Head through dive. The dive was filmed by Yorkshire Television as it happened, and later broadcast as "The Underground Eiger." ...We never published any details of the Speleophone, other than a brief abstract in the Proceedings of the 1977 Sheffield ISU Conference.

Subsequently, Bob Mackin moved to the Engineering Department at Lancaster, and enlisted their aid to further develop the system and market it, under the name of the MOLEPHONE. This, I am told, can be purchased from the Engineering Dept, for 1300-1400 Pounds + VAT, for a pair of sets, batteries and loop aerials. At this price, only the grant-aided Northern Cave Rescue Organizations have been able to buy it. However, both the Settle-Ingleton CRO and the Upper Wharfedale Cave and Fell Rescue Organization now have several systems each, and use them regularly both on practice and actual rescues. I am told that the equipment is so ruggedized and reliable that it is taken for granted, and that the rescue teams have pre-prepared lists of correlated surface and underground locations for all the major cave systems in their respective areas. There is no doubt that the Molephone now regularly plays an important and time (and life) saving role in cave rescues in the Yorkshire Dales.

I know of three recent British expeditions which used... cave radios. Two were cave diving expeditions to Greece and Norway, both made in 1985, and documented in the Cave Diving Group Newsletter No. 78, January 1986. Filmed reports of both were shown on TV in this country late last year. The third expedition was last summer's CRO/Army visit to the Gouffre Berger and the Scialet de la Fromagere. I... will enquire as to what use was made of the Molephone during the expedition.

As far as I am aware, no use is being made in Britain of cave radio techniques for data transfer from underground equipment or for measuring ground conductivity.

In May, June and July 1986, 3 parts of an article describing the TROGLOGRAPH, a CW cave radio system transmitting at 3.2768 kHz, and designed by Mike Bedford, appeared in the British hobby electronics magazine ELECTRONICS TODAY INTERNATIONAL, published by Argosy Specialist Publications Ltd., 1 Golden Square London W1R 3AB. I contacted Mike through the editor, and found that he was a microelectronics software/hardware engineer working... on CAD graphics display terminals... We have met several times since then, and I have given him copies of all my articles etc., together with SPELEONICS Nos. 1-6. He is trying to re-create your A.S.S. system using ICs currently available in Britain, and operating at the Molephone frequency... We hope to commence prototype tests sometime this year. In particular, we want to examine the spectrum in the 100-200 kHz band to find the frequency with the least RF noise consistent with acceptable attenuation through limestone with 5-10m bog and drift cover, and to experiment with ribbon cable loop antennae to find a design giving a depth range of 200m+ without being too cumbersome. We will keep you posted...

One of the problems we face in this country which does not appear to trouble you so much in North America is one of licencing. It took me a lot of time and a visit to London to get even a develop-

(**LETTERS** continued)

ment licence for the Speleophone, and I do not know what licencing arrangements are necessary for the Molephone. Once I find out, I will let you know so that the details can be published in Speleonics. In addition, I will try to get a general article published in the BCRA Caves and Caving Bulletin mentioning Speleonics, and requesting all interested British cavers to get in touch with you and I and suggesting they become subscribers. We might end up with our own specialist BCRA Communications Section!

Regards,

Dick Glover
258 CROSS FLATTS GROVE,
BEESTON,
LEEDS LS11 7BS.
United Kingdom
Phone: (0523) 701062

[Sidebands of the 100.0-kHz LORAN-C navigation system (see SPELEONICS 5) might cause interference. The LORAN transmitter nearest the British Isles is in West Germany. There are 14 LORAN stations in continental US (more are planned) and 11 in Canada and Alaska. --F. Reid

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Dear Frank,

Thanks for the Smart Compass plans [see SPELEONICS 6]. I've ordered one of the coils to experiment with. I disassembled the code and found out how it works: T and L are sin θ and cos θ. They are divided in software to give tan θ over 0-45°. An arctan is done via table lookup, corrected for quadrant, and displayed. The accuracy is ultimately limited by the coil winding accuracy (i.e., T & L are exactly 90° to each other). To get sub-degree accuracy will require a better A/D and bigger arctan lookup table, but that's easy. I'll keep you posted.

Jim McConkey
7304 Centennial Rd.
Rockville, MD 20855

Someone requested information on WWVB receivers. We lost the letter, but here are some references:

WWVB is a time/frequency-standard station operated by the National Bureau of Standards at Fort Collins, Colorado. The 60-kHz frequency is relatively free of propagation-anomaly errors. Time information is digitally encoded; see [2] below:

1. "A WWVB 60 kHz Frequency Comparator Receiver" by Ernest P. Manly appared in 73 Magazine, Sept. 1972. The now-obsolete RTL integrated circuits in this design can probably be replaced with CMOS. It's similar in function to the Hewlett-Packard 117A VLF Comparator but has no phase-locked oscillator output.

2. Don Lancaster published plans for a 60-kHz WWVB receiver with time-code output, in Radio Electronics magazine, August 1973, p. 48. Methods of phase-locking are discussed.

3. "Low-Frequency Receiving Techniques," a series of articles by R. W. Burhans in Radio Electronics, March-July 1983, describes state-of-the-art LF/VLF active antennas, and a method for using LORAN-C (100 kHz) for time and frequency calibration. These are valuable references for cave-radio experimenters. A set of reprints, with errata/addenda, is available from the author for $4.00 postpaid:

Burhans Electronics
161 Grosvenor St.
Athens, Ohio 45701

Send SASE for catalog. See also Dr. Burhans' three-part article about Omega navigation receivers (10-14 kHz) in Byte magazine, February, March, April, 1977.

EMERGENCY WATCH-REPAIR FOR CAVERS

Frank Reid

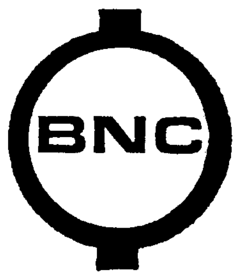
I've successfully repaired several cavers' digital watches which failed after taking water during cave trips, just by opening the cases (as soon as possible), removing and drying the batteries, and putting the watch guts in a warm (not hot) place for a few hours. An electric hand-dryer also works-- A National Cave Rescue Seminar participant was amazed to see an electronic watch repaired in a National Park campground bathroom, using only a Swiss Army knife!

Clean all battery terminals and contacts before reassembly (I use a pencil eraser). The only difficult part is making sure that pushbutton contacts are not bent during reassembly.

Here's more watch-repair advice, received through <rec.ham-radio> an international computer-mail distribution. It was signed "Joe N2XS":

When taking-apart digital watches it is important not to touch anything inside with your bare hands. The DNA from your skin is enough to cause a bad contact. Almost all problems with digital watches are contact or battery problems. Dampen a VCR cleaner swab or lint-free cloth with tuner-spray and clean all visible contacts. Do not spray the inside directly from the can. Also, look for bent contacts; they are very small and easily damaged.

YOU, TOO, CAN BE A BIG-NAME CAVER!



Just Xerox the above emblem on colored paper, cut out, glue onto an old political campaign button, an wear it at the NSS Convention!

WHERE THE SUN SOMETIMES SHINES: SOLAR POWER AT A CAVE RESEARCH FIELD STATION

Howard A. Hurtt, KB6KSO

Lilburn Cave in Kings Canyon National Park, California, has been known to cavers since the mid-Fifties, and has been the subject of intense mapping and baseline scientific studies by the Cave Research Foundation (CRF) since 1980. Lilburn boasts 12 km of passage and a resurgence with bizarre chaotic ebb-and-flow characteristics.

The cave system's unusual hydrology was discovered in 1968, and instrumentation was completed at the resurgence and at the terminal siphon in the cave in 1973. The equipment consisted of potentiometric pressure sensors controlling VCO's at each location to convert water depth to frequency. This was landlined to a dual-track tape recorder at the fieldhouse. Segments of the seven-day record obtained were treated with a 2-channel F/V converter to produce synchrograms of siphon and resurgence water levels.

Although the project was beset by problems, including lightning damage, destruction of surface lines by animals and limb-fall, washing away of the resurgence instrumentation by record floods, and subsequent loss of the data tape, the siphon and resurgence water levels were proven to mirror each other. In the bargain, the roughly 6,000 feet of quad D (indoor telephone wire) running from the siphon to the surface has remained in excellent condition for 13 years.

The telemetry line has been used since 1975 as part of a dry-line telephone system, and has failed only twice: once from corrosion at a twist-splice, and once from being mashed by a rock kicked loose by a caver high above. After a string of interim phone systems proved their merit in improving organization and safety in this hostile cave, it was decided that something more substantial and permanent be built.

Until 1980, reasonably stout vehicles could be driven from the nearest paved road down seven miles of ruts leading to the door of the field station. At this time, the NPS wisely began managing the area as wilderness, a policy which, among other things, excluded motors. This caused an immediate communication crisis. The project had been clipped into handy car batteries to run the cave phone and also the re-tuned Systcoms VTR3 mobile phones with which radio contact was maintained with Park HQ. The cave phone was quickly adapted to a 6V headlamp battery, which would run it all season. The mobile phone, however, with its 30W all-tube transmitter, drained a motorcycle battery every trip, which had to be packed in and out. Electric cavers had also become accustomed to recharging their headlamp batteries on the site. We decided we had to either junk the dinosaur radio or learn to make our own electricity, or both.

POWERING DOWN

Project management cast about for proposals to solve the problem of the power-hungry radio. A mini-hydroelectric plant operating at the resurgence was seriously considered until the fate of the telemetry line across the same route was recollected. There was also some concern about what NPS would think of the idea in a wilderness. The outcome of that meeting was that we should think in terms of powering-down so that at least batteries wouldn't have to be carried in as often.

Chris Royce, KF6IO, donated a Regency HR-2B to the cause, expressing some doubt whether it could be tuned upward 20 MHz to the NPS frequency. It could, and the Systcoms was retired. A 3-element Yagi was assembled from 12-gauge (2.053 mm dia.) solid wire hidden in 3/4" Schedule-40 PVC. In the 1.5 W low power mode, the Regency easily brings up the NPS repeater on a ridge 9 miles away.

The radio was mated to the cave phone so that they shared a common power supply. The phone line was matched to the receiver's audio amplifier input and also to the microphone input, and receiver audio was superimposed on the phone line (Figure 1). This provided something very much like a continuous phone patch. Although it has not been used in an emergency, the patch has been tested, and work well.

Eight taps were provided along the line in the cave, either at important intersections or near particularly obnoxious spots on main routes. When a cave party clips a conventional phone handset onto the parallel wire pair, a 40 mA current loop is completed which latches an SCR. This powers a ring generator (Figure 2), which produces a high-low tone with about a 10 Hz shift rate, interrupted about every 2 seconds. This is heard loudly at the receiver speaker, and stays latched until the field station handset is picked up. Picking up the field station handset completes the speech loop, and also enables the transmitter and starts a logging recorder.

The phone system uses two of the 4 conductors in the D wire. The other two are reserved for instrumentation.

THE POWER SUPPLY

The only sane power supply for the project appeared to be solar. But where would we find sun in a mature forest where most of the trees were pushing 200 feet? The Lilburn field station is on the flank of Redwood Mountain, home of the largest of the Giant Sequoia groves. Even a small tree in these parts can be damn big, and cast a big shadow. So why not put a solar collector up in a tree? Ridiculous! You'd have to go up a hundred feet or more, and the voltage drop in the down-leads would be unacceptable. Furthermore, the mounting bracket would mutilate the tree.

"Not so," said Dave Zoldoske, who just happened to know where he could get his hands on 200 feet of 6-gauge (4.115 mm) 2-conductor street light wire. "Not so," added Mike Spiess, a master welder and former treetopper, who would build and install the gentlest of brackets, with turnbuckles to adjust for the growth of the tree.

With binoculars, clinometers, and well-tempered enthusiasm, we surveyed the five or six most likely trees near the field station. The winner jumped out at us. On a slope about 20 feet south of the cabin was a majestic white fir with a 41 inch diameter trunk. The tree had a distinctive compensation curve from the creeping of the soil of the slope, but above was sound and straight. At about a hundred feet up, it looked as though a gap in the canopy was illuminated over the tops of adjacent shorter trees to the south for most of the day. We would have to climb it to be sure.

Spiess, dragging a measuring string and free-climbing the bark, got into the lowest branches 55 feet off the ground. Here, at last, he could put sling loops around limbs for protection. He attained the gap in the canopy at 130 feet, and surveyed the solar window. With the trimming of a few small interfering branches, it would be nearly perfect. The trunk was 26 inches in diameter at that point, and the top of the tree looked to be another 60 to 70 feet higher. He put in a permanent anchor and retreated.

While the tree search was going on, I had been investigating solar collectors. The first price sheet I saw convinced me that we would have to charm someone out of a collector. I put out several feelers, offering publicity in exchange for samples. In January of 1983, Gabe Amaro of ARCO Solar International, Inc, responded. ARCO Solar publishes ARCO Solar News, a review of novel photovoltaic applications. Ours sounded novel enough, and a week later we were caressing two shiny new ARCO M-81 modules. These are half-amp collectors designed to charge deep-cycle lead-acid batteries. Amaro had also included plenty of advice on mounting, charge regulation, and lightning protection. I turned over the collectors to Spiess for bracket fitting, and began work on the charging circuitry.

We had bought a Donley 45 AH deep-cycle battery and packed it, fully charged, to the field station in hopes of never having to carry it out again. It ran the communication gear for six months without recharging, then promptly came up to full charge when the photovoltaic system was attached. Since then, we have added a 105 AH battery, and both seem to be faring well.

The charging circuit (Figure 3) consists of a 1N6096 Schottky as a blocking diode (Solar Power Corp. 1980), and a comparator that pulls in a relay to add 5 ohms to the circuit to drop the charge rate to a maintenance level of about 300 mA when the battery reaches 12.6 V (Byers 1984). The normal rate is about 900 mA.

As can be seen in Figure 4, most of the system wiring is devoted to distribution and lightning protection. There is a 12 V 20 A utility outlet on the main panel, and also a 2A instrument power outlet with supplementary transient protection. In addition to the communication package, the 12 V bus also runs two simple headlamp battery chargers and a 30 W self-inverting fluorescent light of the sort used in RV's. The fluorescent was an almost absurd afterthought. It had been found in a trash bin behind a Winnebago dealership, tubes intact, with its switching transistor burned up from inadequate heat dissipation. The transistor was just pop-riveted to the thin aluminum reflector. For the investment of a more substantial heat sink and a cheap generic transistor, we had acquired a very efficient way to light the interior of the fieldhouse.

Lightning is a big problem on Redwood Mountain. Warm, wet Pacific air is cooled as it goes up the west slope of the Sierra Nevada, generating a line of thunderstorms that can sometimes last for weeks. These storms often produce more electricity than water, resulting in frequent fires. One reason NPS insists that we man a radio at the field station is for reporting fires. We learned our lesson about lightning in 1974 when the surface telemetry line got blitzed, but instead of retreating we went for technical countermeasures.

The surface line from the field station to the Meyer Entrance, a distance of about half a kilometer, was replaced with two parallel runs of 2-conductor copperclad drop wire. This is the abundant, cheap, and tough material used to bring phone service from pole to house. It is miserable to work with, but holds up well against falling limbs and gnawing forest fauna. Where the surface line enters the fieldhouse, it is attached to Western Electric signal circuit protectors, as is the drop wire that enters homes. These are fuse-like devices that respond to spikes of 200 V or more, shorting the offending line to earth until the element is replaced. Signal circuit protectors are also used at the fieldhouse tiepoints of the solar collector downleads.

Three other types of transient protection are used in the power and landline systems. Where the solar collector leads enter the distribution panel, a TII-317A surge arrestor, provided by ARCO protects both positive and negative leads. This is a gas-filled spark gap which fires at about 60 V, momentarily shorting the lead to ground. Downstream of the 317A is an LC network within buffers any voltage with a risetime shorter than about 2.5 microseconds. As the telemetry lines enter the panel, they pass through quick-blow 250 mA instrumentation fuses, and are then bypassed to ground with 130-V MOV's. Downstream are LC networks. If either the MOV or the bypass capacitor of the LC passes substantial current, the fuse will be opened, and subsequent injury to the system prevented.

Although some parts of the design may seem crude by contemporary standards, this system has been in operation for more than five years, and has yet to suffer even so much as a blown fuse. This testifies either to the robustness of the design or to an unseasonable lack of lightning activity. The ability to recharge caving headlamp batteries using solar power at a long-term cave research project site is, as far as we know, unprecedented. It also lends a prosaic twist to the line in the well-known cave ballad.

I would like to hear from anyone else with experiences or comments on unusual applications of photovoltaics. I believe that, once one gets access to the collectors, the rest is easy. Particularly welcome would be commentary and criticism of this system.

Correspondence should be addressed to:

H.A. Hurtt
4763 E. Illinois Ave.
Fresno, CA 93702

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Byers, T. J. 1984. A photovoltaic battery-charge controller. Mother Earth News 1984 (2):98-100.

Solar Power Corporation. 1980. Solar electric generator systems. Anon. pamph., 11 pp.

Figure 1

COMMUNICATION CONSOLE

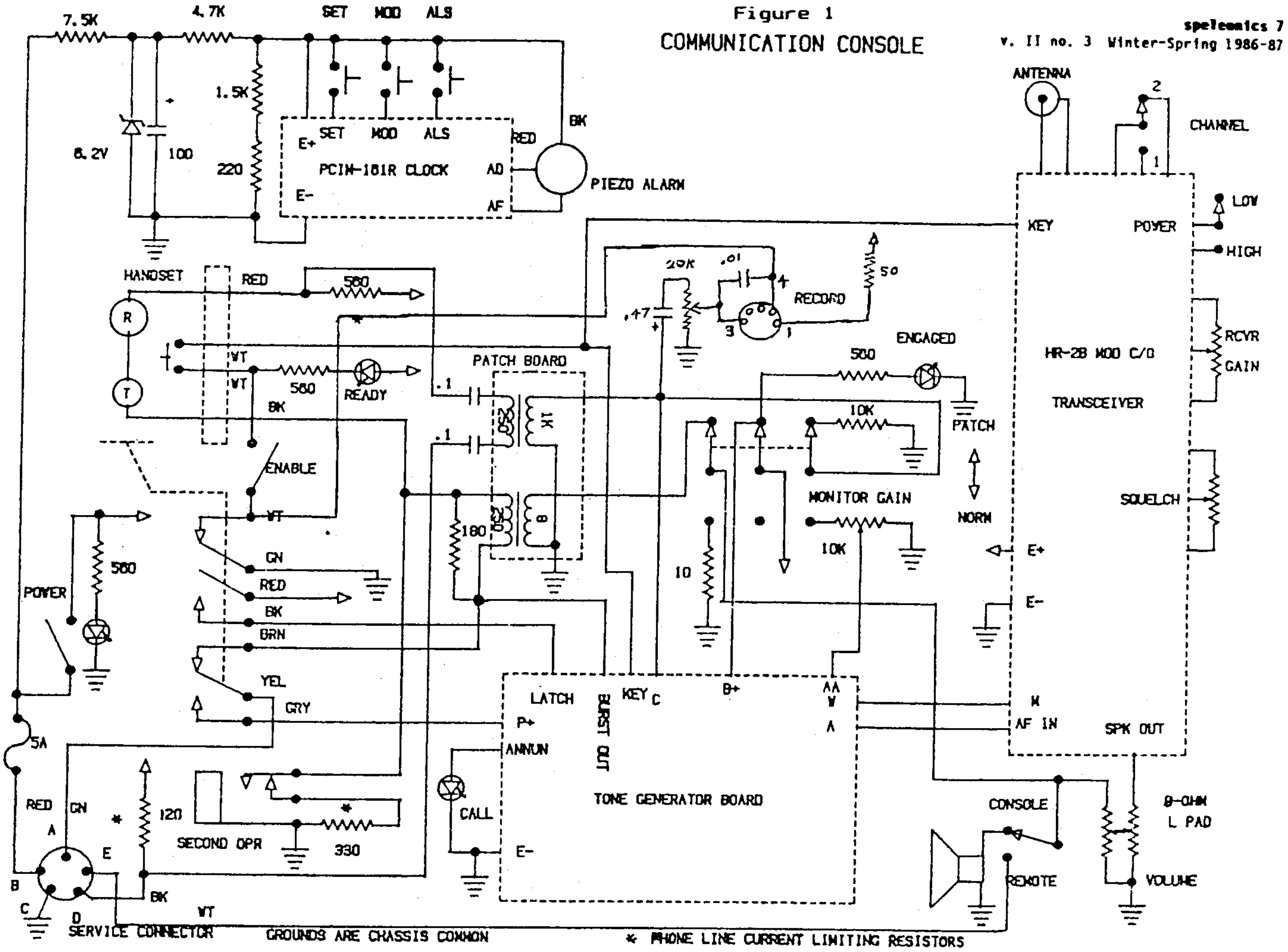


Figure 2

TONE GENERATOR BOARD

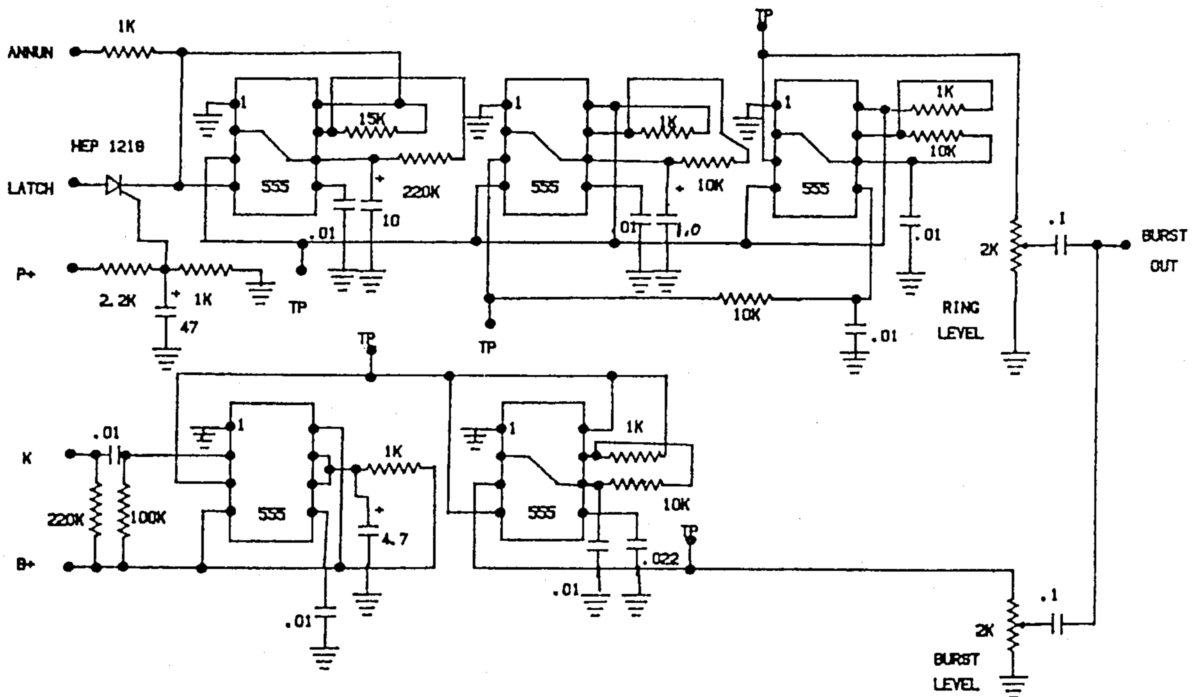


Figure 3

CHARGE REGULATOR

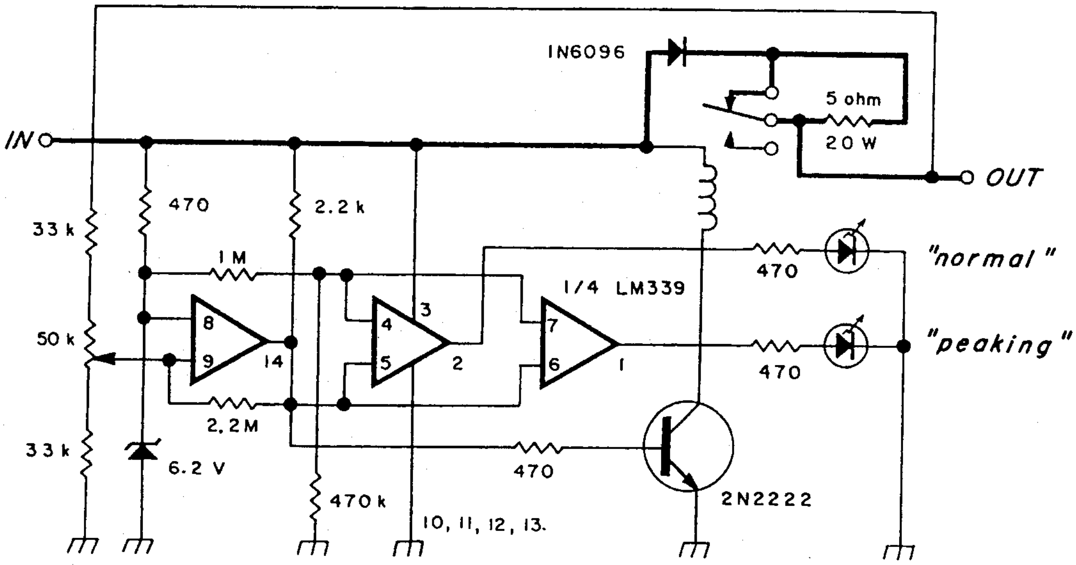
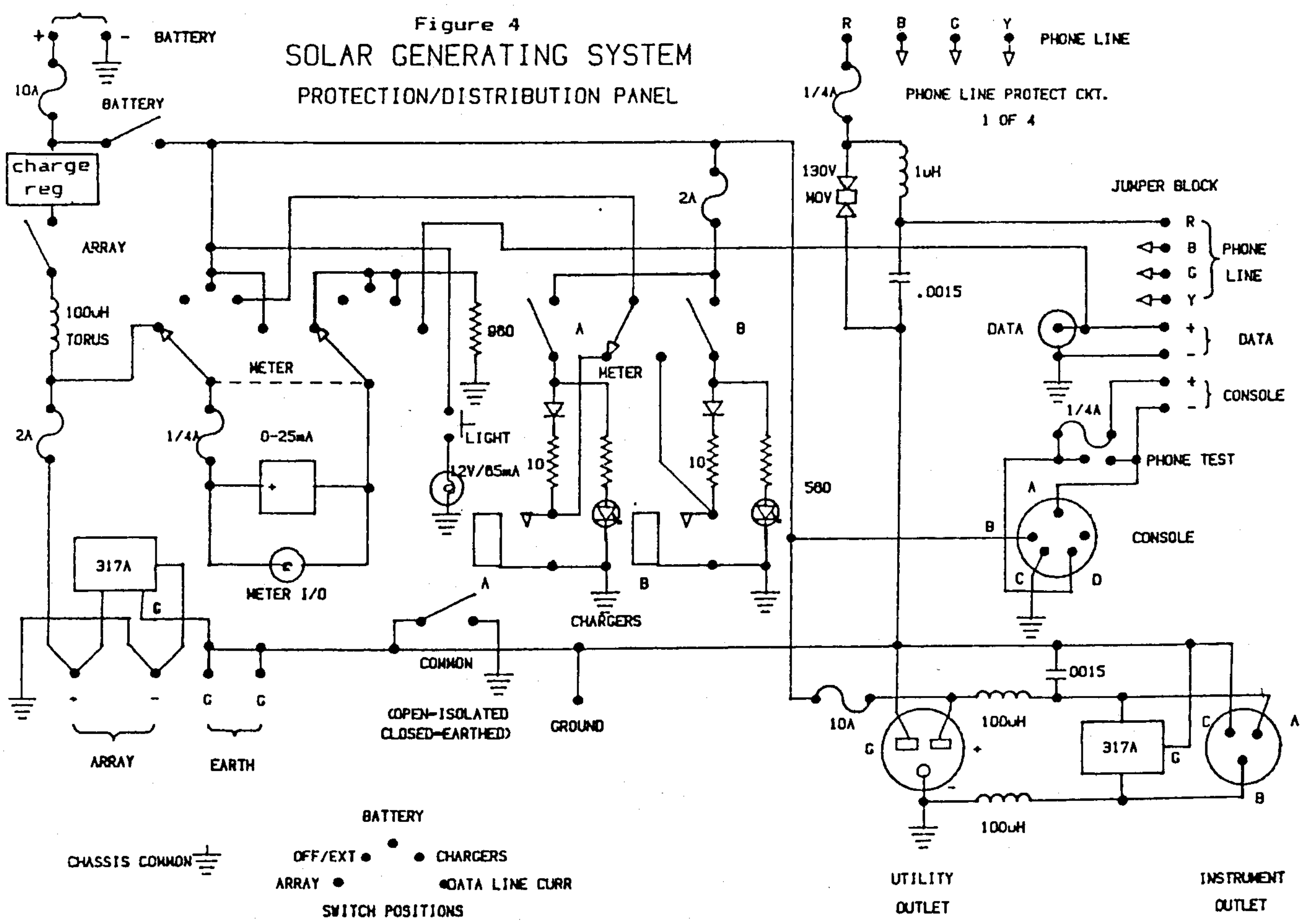


Figure 4

SOLAR GENERATING SYSTEM

PROTECTION/DISTRIBUTION PANEL



CAVE RADIO M-85

Bo Lenander, SM5CJW *

After years of calculation, experiments and just making the equipment, it is ready-- an easy-to-use direction-finding and communicating device! This equipment uses double-sideband (DSB) transmission/reception; the informationless carrier is greatly reduced and takes less energy from the batteries. The cave and surface units are identical and weigh 700 g, including batteries. The antenna weighs an additional 600-1350 g. **Transmitter peak power is about 1.5 W and the frequency is 32768 Hz.** The microphone input has automatic level control with long decay-time so the modulation level will be the same if you are whispering or shouting into the microphone. The receiver also has audio AGC, with a decay time of about 1 second and that is very convenient when using it for direction finding. An external headphone can be used in noisy environments, and then the built-in speaker operates only as a microphone. Speech quality is comparable to MW or LW broadcast stations. Each unit has eight 1.5 V, size R6 (or AA) alkaline cells. The units are not completely waterproof, but water resistant. The p-c board is protected by lacquer and all switches are magnetically controlled and glass-encapsulated. Each unit consists of 13 IC's, 10 transistors and 106 other components on a printed-circuit board, 60 x 115 mm.

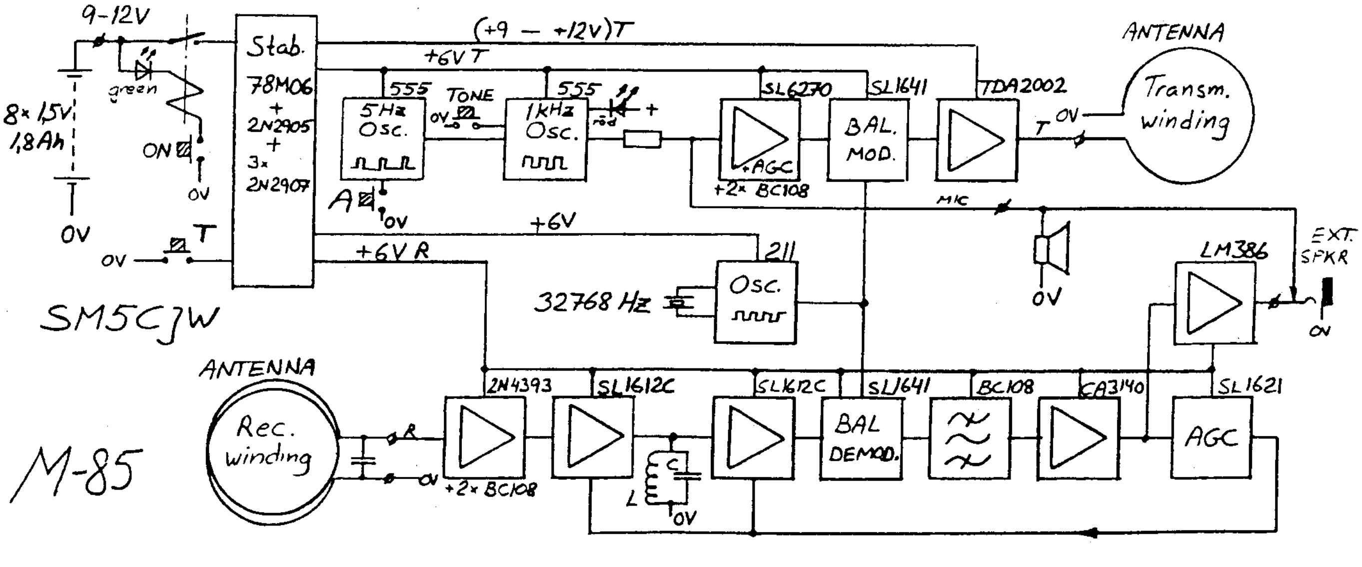
A Short Description of the Function:

ON/OFF is controlled by a relay and indicated by a LED. The high-current double contacts of the relay connect to a 6-volt regulator. A distributing circuit gives voltage to the transmitter when the T-button is pressed, and to the receiver when the T-button is released. Pushbutton **A** activates a pulse-generator controlling a tone generator, making a sequence of short tone bursts. Pushbutton **TONE** is used as a key to send morse code. A microphone amplifier with automatic level control feeds the balanced modulator. The carrier oscillator is built around an electronic watch crystal, and is used for both reception and transmission. The transmitter PA is an audio amplifier IC that has proved useful up to 100 kHz. The receiver input is high-impedance and therefore the Q-value of the antenna is high, giving good sensitivity and good signal/noise ratio. The two following amplifiers are AGC-controlled. A resonant circuit between the amplifiers reduces the HF bandwidth. The demodulator is the same type of circuit as the modulator. An audio bandpass filter with an amplifier drives the audio output stage and the AGC circuit. Microphone input and receiver antenna are not disconnected during transmission, therefore, the transmitter and receiver inputs have protection circuits. All microcircuits of type SL___ are made by Plessey, for professional communication equipment.

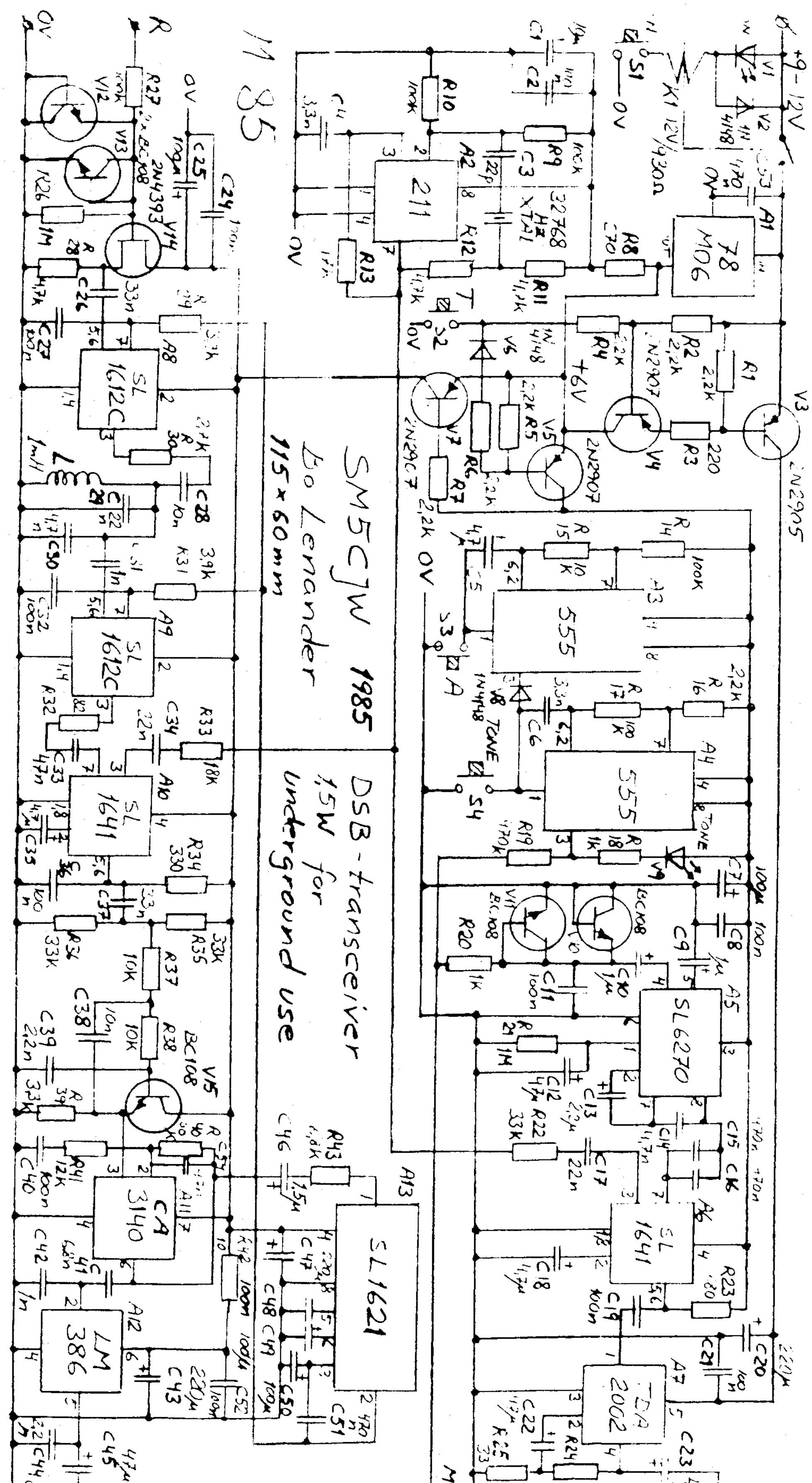
Antennas:

Two antennas have been made for use in caves. One is a shielded 18-wire cable connected as an 18-turn receiver coil with 1 m diameter. The shield (1 turn) is then used as the transmitter coil. This foldable antenna weighs 1000 g and can be used for communication up to 200 m distance. The other underground antenna is made of 12 ferrite rods (D = 10 mm, L = 200 mm) in a bundle with a 300-turn receiver coil and a two-turn transmitter coil wound on it. A spirit bubble level is mounted in the end, making it easy to orient the antenna vertically when using the direction-finding mode. This antenna weighs 1350 g and can be used for communication to 80 m distance. The surface unit has a loop antenna of 420 mm diameter with a 300-turn receiver and 1-turn transmitter coil. The weight of this loop antenna is 600 g and it is very useful for direction finding.

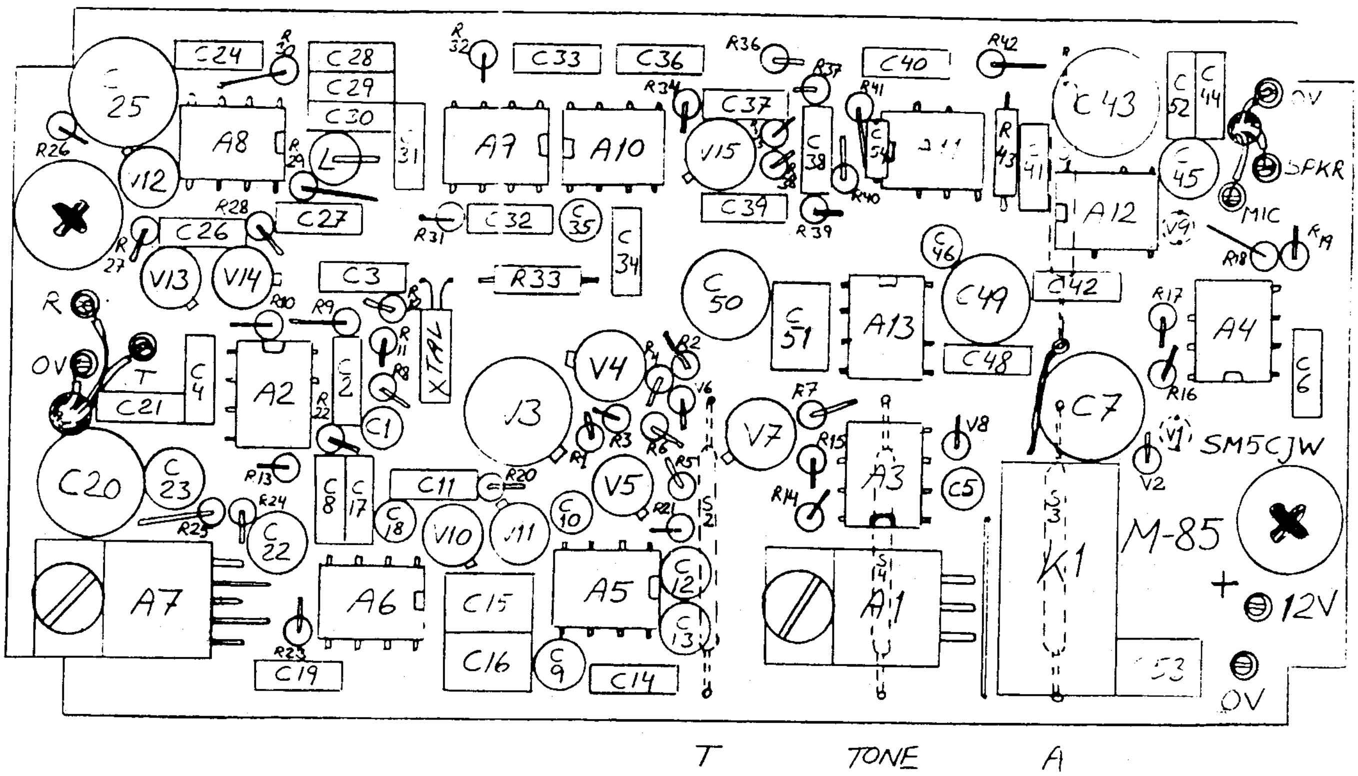
* Kultyxgatan 16
S-723 51
Vasteras, SWEDEN

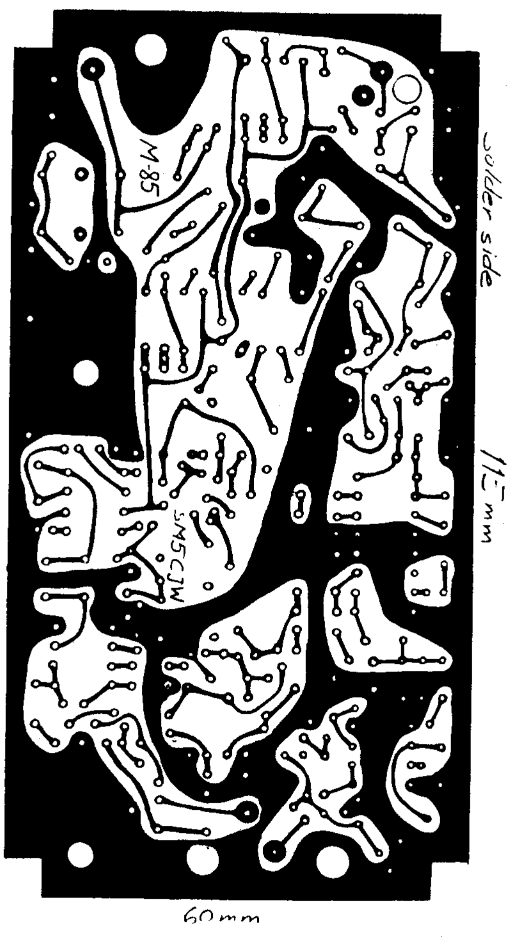


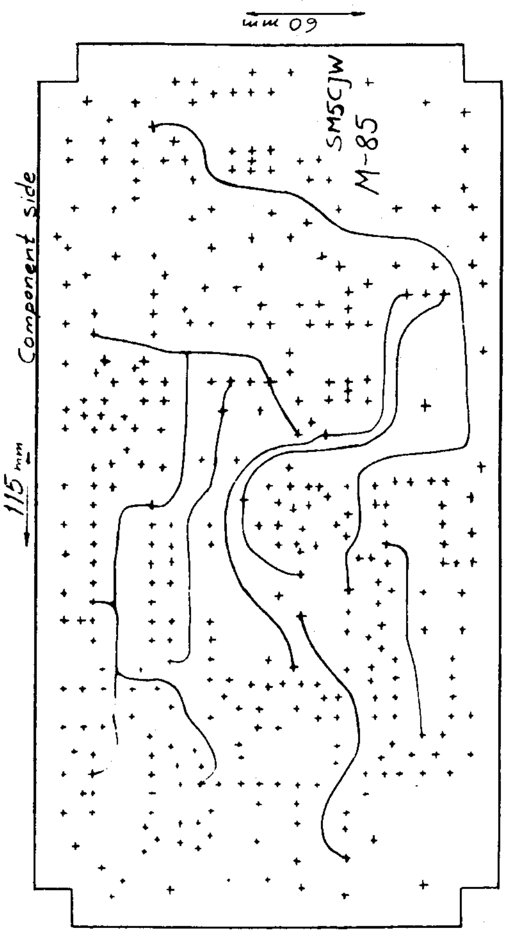
Block Diagram


SM5CJW 1985
Bo Lenander
115 × 60 mm
DSB-transceiver
1,5W for
underground use

Note that some pins of the ICs have been cut (= not used).







MAGNETIC MOMENTS #5: THE PHASE PROBLEM

by Ian Drummond

Many discussions of cave radio technology have centred on the problem of obtaining maximum range by choosing an "ideal frequency" of operation.

The earliest work recognised that the lower the frequency, the less the attenuation of the magnetic field by the conductive rock, but little recognition was given to the effect of atmospheric noise. In 1970 Nevin Davis published a quantitative model (1) which predicted among other things that frequencies as high as 1.8 MHz would be useful for voice communication. Davis actually made the pessimistic assumption that the magnetic field was subject to exponential attenuation by the earth. In fact the weakening of the signal is less severe, and consequently the higher frequencies will be even more useful than Davis predicted.

A very useful description of the work done by the US Bureau of Mines is reported by Linfield (2) and gives optimum frequency curves for CW (Morse) signals (Fig. 1). Similar curves could be developed for voice communication. Linfield reports the best frequency for voice communication, when limited by mine electrical noise, is 30-40 kHz at 100 m depth.

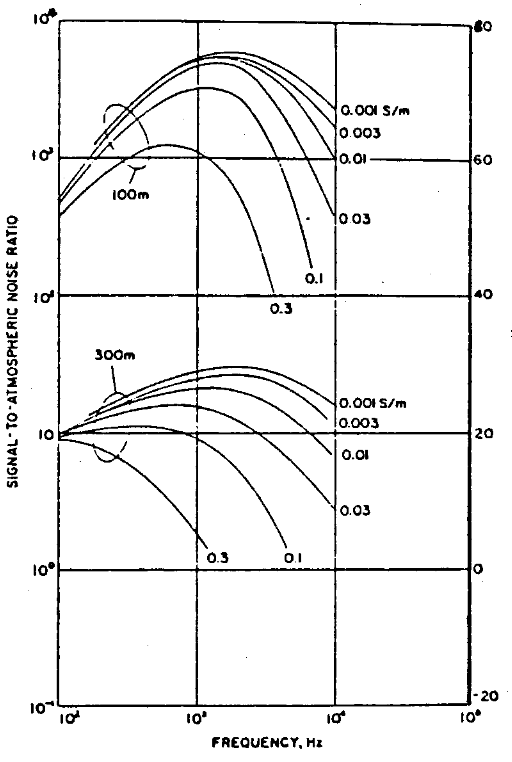


Figure 1. Ratio of magnetic field strength to atmospheric noise on the surface directly over a transmitting loop with magnetic moment of 1000 (amp·turns·sq metres). Receiver bandwidth is 10 Hz. Path lengths of 100 m and 300 m are shown, with ground conductivity of 0.001 - 0.3 mho/m.

My conclusion from all this information is that practical communication systems can work at depths exceeding 100 m for a wide range of frequencies, from 3 kHz (CW) to over 100 kHz for voice.

There is, however, a further problem not considered in the above models, which may influence the choice of frequency for a cave radio system. I call it The Phase Problem, and it arises because of the way cavers use the geometry of the magnetic field to locate the position and depth of the transmitter. All the current methods (3,4) rely on rotation of a loop antenna until no signal is detected, at which time the plane of the loop is parallel to the oscillating magnetic field. Unfortunately the effect of the conductive ground is not just to weaken the intensity of the magnetic field, but also to induce a component which is out of phase. As a result the magnetic field on the surface above the cave is no longer plane-polarized, but rotating. Its directional characteristics are weakened and a broad signal minimum only can be detected. This effect is more marked with increasing depth of the transmitter and with increasing distance on the surface from the null-point above the transmitter. The effect can become so extreme that all directional sense in the signal is lost and a strong signal is received whichever way the antenna is rotated. The effect is much more noticeable when measuring depth than when locating the null-point with the antenna plane vertical.

Based on my own experience with the ASS cave radio operating at 115 kHz, I feel I can get reliable null locations to depths of 150-200 m, but depth determination is difficult when the antenna is deeper than 100 m. Even when the antenna is shallower, there is difficulty getting directional signals at horizontal distances exceeding 2x the depth from the null-point (although voice communication is perfectly clear).

The subject has been treated theoretically by J.R. Wait (5). Two graphs from the paper are shown here (Figs 2 & 3). The conventional method of measuring depth assumes H = 0, and P/Q is measured directly as 1/Tangent(antenna angle at null). In the real world, as H increases (due to increasing depth of transmitter, or increasing conductivity of the ground) the null angle of the antenna is harder to detect as the phase angle of P/Q deviates from 0° or 180° (Fig 3). Moreover, the value of P/Q estimated from the angle of minimum signal gives increasing error in the depth estimate if it is used in the equations which assume H = 0. (Fig. 2)

All these effects are minimized if the surface receiver is near the null-point on the surface (D = 0). Therefore if the operator of a cave radio does observe these problems, at present the best solution is to move closer to the null point. This may involve a box-search of an area if the signals have no directionality at all, as has happened to me on occasion.

Conclusion. As radios improve and their range extends, new considerations will determine the best operating frequency. For long range voice communication, frequencies above 30 kHz will probably prove best but position location work will be limited to depths less than 150-200 m. For location work at greater depths, lower frequencies will be needed. The common 3.5 kHz frequency will probably work to depths up to 500-600 m depending on the conductivity of the earth.

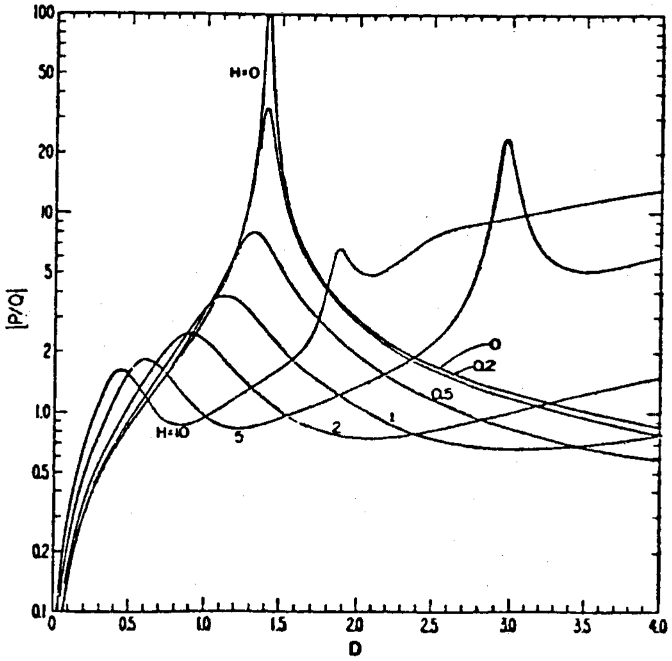


Figure 2. The ratio of the horizontal/vertical magnetic fields on the surface over a horizontal buried loop antenna.

D = horizontal distance from null-point/depth of the transmitter.
H = 1.414 x (depth/skin depth)
= 0.0028 x depth(m) x (conductivity x frequency)
(See Speleonics # 1 for skin depth concept.)

The classical method of depth determination assumes the frequency = 0 and therefore H = 0.

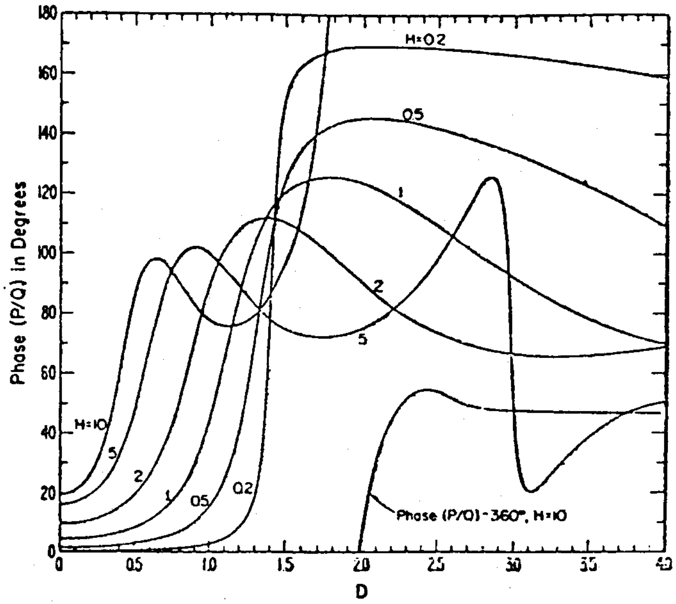


Figure 3. The difference in phase between the horizontal and vertical magnetic fields on the surface over a buried loop antenna.

Classically the frequency is assumed to be 0 Hz, so H = 0 and the phase difference is 0 or 180 degrees. (The change from 0 to 180 occurs at D = 1.414 where the magnetic field is horizontal).

In practice, as D increases or as H increases, the phase angle increases too, so the signal nulls become broad minimums as the loop antenna is rotated.

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(2) Linfield R.F. An Overview of Underground Communications. Westinghouse Georesearch Laboratory, Boulder, Colorado

(3) Mixon W., Blenz R. Locating an underground transmitter by surface measurements. Reprinted in Speleo Digest 1964, Page 3-1.

(4) Glover R.R. Cave Surveying by magnetic induction. Surveying caves. (Editor Ellis B.) British Cave Research Assoc. 1976

(5) Wait J.R. Criteria for locating an oscillating magnetic dipole buried in the earth. Proceedings of IEEE, Letters, June 1971, 1033-5

QRP TRANSMITTING AND RECEIVING ON 800-1000 Hz (305,000 meters!)

Rick Wright

[Reprinted by author's permission from The Lowdown, January 1987, p. 27.]

The October '86 issue of the LOWDOWN listed my "ULF" beacon, 800ULF, at 0.8 kHz. This ELF-type transmitter is based on an IRF-511 transistor with an automotive spark coil's primary wired between the drain and a +12v to +15v supply. The high tension lead is connected to an elevated 150 ft longwire, and the IRF 511 source is attached to an extensive ground system. More than anything, this low-powered beacon (currently 1.8 watts) offers an opportunity to test ELF-range receiving gear.

In its original mode, the beacon may be driven by an 800 Hz free-running audio oscillator. However, I am now also running an exceedingly coherent signal at 983.39125 Hz based on network TV's horizontal frequency. I have externalized an inexpensive TV's horizontal oscillator output (6v p-p from the emitter circuit). Because of the TV's floating ground, the signal must pass through a buffer amplifier and an optoisolator so that it may be referenced to the transmitter's ground. The shaped signal is then divided by 16 using dual-D flip flops to arrive at the above-quoted frequency. The divider output proceeds through a buffer to the IRF-511. The final buffer is keyed by a C-64 computer. Let the reader beware if he decides to build such a circuit because high voltage audio is a shock hazard - the high tension lead lights neons in proximity!

With a sprig of wire attached to an oscilloscope and merely held near the coil, the output waveform is easily observed. I can freehand sketch a better sine wave, but is it a reasonable, fairly smooth sine approximation - Most of the received harmonics are below the 5th. The rig creates quite an E-field. My daughter complains that it is getting into her portable stereo!

In the matter of designing ELF-range receivers or transmitters, I claim absolutely no expertise, and the enclosed circuit is based on a lot of trial and error and blown field-effect transistors. Using this receiver, I obtained the following results: with an eight-foot whip at the FET's input and 1.8 watts running at the transmitter, I was able to receive 800ULF at exactly one-half mile - weak, but definitely readable. This must surely be the transmitter's antenna field, and it falls away much more steeply than the inverse square law would predict. It can't be a true radiated wave at such low powers and frequencies and with such a miniscule transmitting antenna. Nevertheless, the range was more than I expected - I thought I was doing well in my earlier tests when I was able to receive the 800 Hz signal out to 600 ft! The receiver must be fairly sensitive as it is dominated by static crashes if the gain is turned up.

The preamplifier (high to low impedance match) has a 10 megohm gate-to-ground resistor, and I suggest closing the grounding switch when it is not in use. The tunable audio active filter follows the preamplifier, and in my opinion, it must be in that position and not at some later stage - it is analogous to the preselection of an RF amplifier. However, if the filter is bypassed, the OMEGA stations come through very strong. Using the Burhans VLF/LF converter/Sony receiver combination, this front end receives well up to WWVB, and the LORAN-C signals are still fair at 100 kHz. This circuit is my best means for receiving OMEGA-range signals.

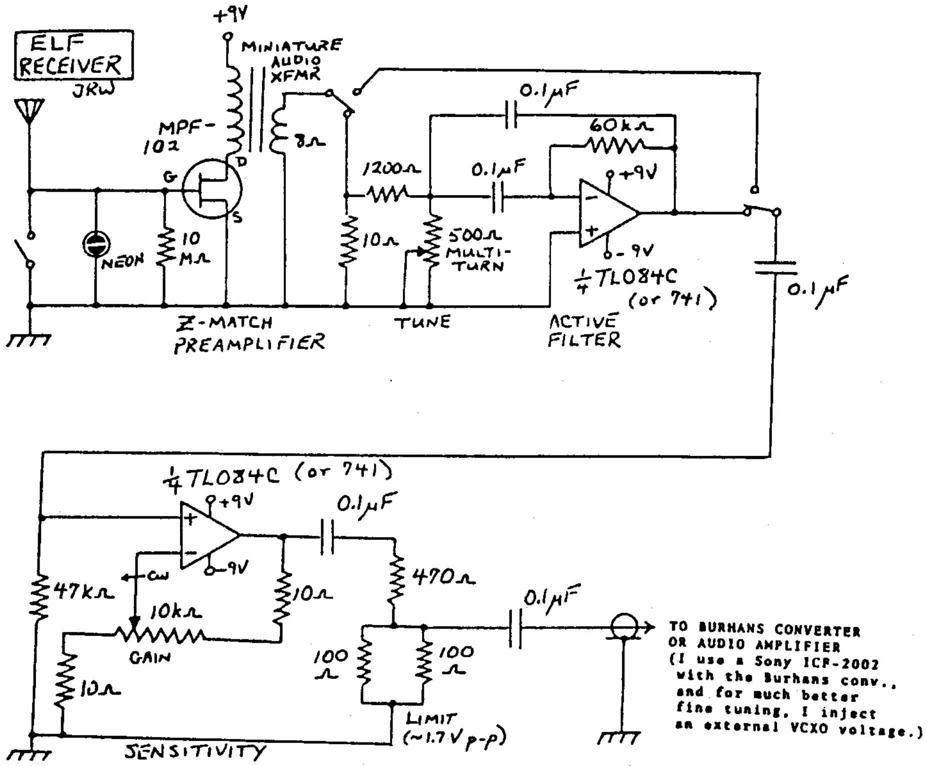
The op amp gain stage after the filter allows optimizing the receiver's sensitivity relative to the noise floor. At the suggestion of Ralph Burhans, the output signal is limited to 1.7 volts to avoid overdriving and burning out his VLF/LF converter (or perhaps an audio amplifier). There are actually two options in receiving signals. First, if the signal is in the range of good hearing (such as 983 Hz), the 741 output can be routed to an audio amplifier such as a C-60 cassette player, and this works well - I've tried it. The second option is to play the audio into the Burhans converter and receive the signals near 4 MHz. For signals in the best hearing acuity range, switch the BFO off and tune to bring the 4 MHz carrier partly into the receiver bandpass. With the input gain properly adjusted, the 4 MHz carrier bleeding through the balanced mixer along with the modulation sidebands become, in effect, an AM signal. However, the main advantage of using the Burhans converter is in being able to use the receiver's BFO, and it even works at 983 Hz! You can create a lower beat frequency and use a much narrower active filter on the receiver's output. This feature becomes even more important going upwards from 1 kHz. If one uses direct audio amplification or the receiver "AM" mode, the front end just be kept remote from the speaker or headphones since positive feedback will cause oscillation. A length of coaxial cable is recommended. The BFO mode gets around this problem. I note that the whip antenna will introduce microphonics even in a mild breeze.

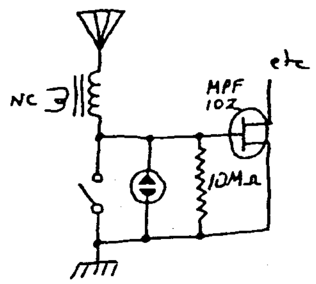
I have also tried radiating the TV's divide-by-four frequency (3933.565 Hz - "4000VLF"). Using the BFO option and without an intervening active filter (I need to brew one for that range), the 4000VLF signal reached to one-third mile. In part, this was due to a lower antenna voltage - the coil shows a fearful voltage until you attach the antenna.

I really don't expect vast range increases at VLF/ELF frequencies. In the near future I will test a spark coil to destruction to find its upper limits to input power. I'm more interested in exploiting the coherence already present in the 800ULF signal. The carrier may be obtained at the receiving site (by TV), and if the receiver output is compared with this coherent reference in a phase detector, true coherent detection becomes feasible. One should be able to create exceedingly narrow bandwidths, but the method will involve slow communication rates.

John R. Wright KA5YWH

John R. (Rick) Wright is a professor of chemistry at Southeastern Oklahoma State University. He has done caving in Arkansas. A preliminary description of his 800-Hz work appear in **Western Update #33** (early July, 1986). Rick is presently using digital signal-processing techniques to investigate naturally occurring signals at sub-audible frequencies.





NOTE REGARDING THE FIGURE: The selective element (active filter) shown in this circuit is meant for the 800-1000 Hz frequency range, but its value may be changed to select other audio frequency ranges. See H.M. Berlin, "Design of Active Filters with Experiments," Sams Publications, p139, 1977.

If a strong AM station is nearby, it minimizes intermodulation if you wire an audio transformer's primary between the gate lead and the antenna, as shown. In my case, AM station KSEO is not a mile away. I just wait for it to leave the air before doing experiments, and in that case a choke is not necessary. KSEO gives me a grace period between sign-off and night propagation conditions.

RESOURCES

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Our readers should find things of great interest in Lindsay's TECHNICAL BOOKS CATALOG It features a "lost technology" series of hard-to-find books about old steam and gas engines, metal casting, tool and die making, machining. There are old and new books on electrical things including rotating machinery, Tesla coils, alternative energy. Books on storage batteries are directly applicable to caving. There are unusual books on explosives, perpetual motion, embalming, even a calculus comic-book! Reasonable prices, fast service.

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"TEC-200" image film makes printed-circuit etch-resist masks in electrostatic copiers or laser printers. "Xerox" the artwork on the special plastic film (if necessary, reverse the image first), use a hot iron to transfer the toner (ink) from the film to a clean copper board, then it's ready to etch. Small quantities cost about $1 per 8.5 x 11" sheet. See **Don Lancaster**'s "Hardware Hacker" column in Modern Electronics magazine, March 1987, p. 62. We haven't tried this stuff; it seems promising!

Edmund Scientific
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Edmund is back in its old format, following an allegedly disastrous adventure in marketing "yuppie" toys! The new EDMUND SCIENTIFIC CATALOG FOR INDUSTRY AND EDUCATION is filled with wonderful optical, electrical and other interesting devices for experimenters. They have two catalogs; to get the big "industrial" one, give them a school or company address.

Earthly Impressions
P.O. Box 791
Farmington, NM 87499

Caver/geologist **Barbara amEnde**'s newly-founded rubber stamp factgory specializes in cave and geological themes (see examples in this issue). She is looking for new designs, and does custom work. Write for catalog.

RADON MONITORING IN CAVES

Steven Clark NSS 17221

It seems that the public media have found yet another subject in which they are attempting to incite mass paranoia. The press has discovered that pervasive noble gas, radon, and is distracting the public's attention to its evil nature. We have been told it even lurks in such innocuous places as our basements, crawlspaces, and yes, even caves! As a consequence, agencies controlling access to caves visited by the general public are becoming concerned. This has resulted in interest in developing methods of radon monitoring which are affordable, and suitable to the cave environment.

The carcinogenic nature of prolonged exposure to high levels of radon daughters in mine environments is well documented. Reports of the problem began surfacing nearly 100 years ago. Federal law requires that records of mine employees' radon exposure be kept. Exposure is stated in working levels, and it is currently recommended that exposure be limited to 4 working-level-months (WLM) per year. (One working level is the amount of alpha energy present in a liter of air containing 100 pCi each of the radon decay products Po^{218}, Pb^{214}, and Bi^{214}.)

The Mine Safety and Health Administration (MSHA) has developed a standard procedure for monitoring radon in mines. It requires that a known volume of air, typically 10 liters, be pumped for a known period of time (5 minutes) through fine-mesh fiberglass filters to trap the airborne daughter particulates. The daughter products continue decaying through the uranium 4n+2 series. A 50-minute-wide window, beginning 40 minutes after completion of the sampling, then opens and the Po^{214} alpha decay activity is counted for a fixed period of time. This count is then converted to WL, taking into account a number of factors including counter gross counting efficiency for 7.7 Mev alphas, air volume filtered, and time factor correction.

Scintillation counters are typically used to count the alpha activity on the filter. Ionization-chamber counters are not popular due to low sensitivity. Scintillation counters are typically outside the average caver's budget, they don't fit into reasonable-sized cave packs, and they don't like bumping and jarring. (It should be noted that radon can be detected via other methods such as activated charcoal and specialized plastics, with the latter being used in detectors sold by Teradex. However, their use in cave environments leaves much to be desired. Experience has shown that accuracy, repeatability and reliability are poor.)

Experiments currently underway at Mammoth Cave National Park are investigating the use of silicon detectors to count alpha activity. The detector being used has an active area of 450 mm^2. The detector contains the p-i-n diode, diode bias circuitry, a charge-sensitive preamp, a shaping amplifier, and a single-channel analyser (SCA). (The SCA can be used to perform spectroscopy measurements; this feature is not currently being used.) The detector package is 1.56 inch outside diameter, 1/2 in. high, and weighs just a few ounces. It can be powered by a -12 to -9 volt source.

The detector output is fed through a level-shifting circuit to a simple counter with LED display, powered by 9-volt batteries. The entire package of sampling and counting equipment is easily carried in protective packages in standard cave-packs.

The results to date are very encouraging. Initial crosschecks between the silicon detector/counter and a scintillation counter show excellent correlation. The silicon detector has yet to be calibrated against an MSHA standard and until that step is performed, the data acquired cannot be converted into WL exposure values.

The silicon detector method is very promising because of its portability. The use of a scintillation counter in the cave is generally impractical (even if one could afford it); its size and delicate nature limit sampling to passages which can be exited in less than 90 minutes. This severely limits radon sampling in many caves. At Mammoth Cave, it basically restricts potential sampling to the tourist areas. Using the silicon detector, the range of passages sampled is limited only by the endurance and desire of the caver running the experiment.

The major problem of the silicon detector is its cost. The hybrid package used costs about $800. Consequently, other approaches are being investigated. One potential method would incorporate p-i-n silicon photocells that have surface areas on the same order as those used in the current experiments at Mammoth Cave. This would necessitate development of custom gain stages for the preamp and shaping amplifier, however, this could be accomplished with off-the-shelf components and could also incorporate the counter elements and further reduce the package size.

The sampling project in progress at Mammoth Cave National Park has shown that accurate radon monitoring inside the cave is feasible. While the cost of the equipment has been brought down significantly, it is felt that the cost for the detector can be reduced further with additional work.

RADON SAMPLING IN THE MAMMOTH CAVE SYSTEM

Wm. Karl Pitts NSS 25074

A study is currently underway in Mammoth Cave to measure radon and thoron levels in situ. As described by Steve Clark, this work is carried out using a sophisticated detector which contains both the detector and its associated amplification circuitry in a single integrated package. The advantage of this type of detector is that it is easily portable, and it is possible to measure radon levels anywhere in the system. While there is an active sampling program carried out by the NPS, their sampling is necessarily limited due to the use of large, bulky scintillator detectors. One must be within 90 minutes (travel time) of this detector to use the MSHA-approved Kusnetz method. The small size and rugged nature of the silicon detector free us from this limit, and we can sample at will throughout the system. It should also be pointed out that other methods, such as track-recording plastics and charcoal canisters, are not reproducible to the 10% level needed for this study.

The purpose of this sampling program is two-fold. One major part of the project is to generate a more complete data base for areas which are not routinely sampled by the NPS. The other major goal is to unravel the airflow patterns in the cave using the natural variations in radon concentration due to climatic factors. Mammoth Cave is predominantly flat, and it is known from the NPS monitoring results that the outside air temperature and pressure control the airflow, and hence the radon diffusion in the cave. It should be possible to use the variation of air flow with the outside temperature to passively airtrace the cave, using only the radon and thoron measurements. The preliminary results of our work is encouraging. Various sampling trips have revealed differences of up to 50% along a single passage where there is a known connection to either other passages or an entrance. For example, a trip to Black Kettle Avenue (Coral Avenue on the Kaemper map) showed that the radon concentration varied by nearly 50% on either side of the connection to Big Mother Pit. This pit was possibly Felicia's Dome, and on a subsequent trip the airflow was sampled from Rose's Pass (on the tour route) through the pit, and on into Black Kettle Avenue. This series of measurements indicated that there was indeed a significant air current through the pit, and this current was traced from the upper level to the middle level of the cave. One would expect that the method would work just as well when one doesn't know that there is an air connection!

The assistance of the National Park Service has been crucial to this study, and their cooperation and assistance is gratefully acknowledged.

In Review:

THE OGOFONE

Bob Williams & Ian Todd, S. Wales Caving Club
in
Caves & Caving, Bulletin of the British Cave Research Association, Number 35 - Spring 1987.

The article fully describes an 87.5 or 125-kHz single-sideband voice transceiver for cave-to-surface communication and direction finding, used in Wales' famous Ogof Fynnon Ddu cave system. Range is 500 feet (150m), transmitter power is about 10 Watts peak. The antenna is an inductive loop made from 4 metres of flexible 64-conductor flat cable.

The sophisticated and compact Ogofone is less complex than earlier SSB designs (7 IC's, 13 bipolar transistors, 4 FET's). It uses a NEC uPC1037H balanced modulator chip, an L-C sideband filter, 12-volt / 6 Ampere-hour sealed lead-acid battery, and telephone-style handset. An analog-gate IC handles all low-level transmit/receive switching; a relay switches the antenna. A reported problem with receiver response to the first syllable of transmissions might be remedied by a fast-attack / slow-release AGC circuit.

The Ogofone's ingenious "pip" mode transmits a tone-burst every 3 seconds, with the receiver active in between. This feature is especially useful for establishing initial contact. There is also a continuous-tone mode for direction finding.

contributed by **Angelo George** and **Bill Wilson**

NATIONAL PARK RADIO FREQUENCIES PUBLISHED

Popular Communications magazine, February 1987, featured an article about U.S. National Park Service radio communications. A comprehensive "scanner list" even includes frequencies of private concessionaires that operate within national parks. This previously-hard-to-find information is valuable to cave-rescue and other SAR groups.

contributed by **Frank Reid**

PHONE PATCH CONNECTS CAVE TO HOSPITALS

Frank Reid

It is important to provide direct communication between medical personnel during a cave rescue; relay operators waste time and garble messages containing unfamiliar terminology. Four interconnected radio and telephone links allowed **Dr. Noel Sloan** to talk to an Indianapolis hospital from inside Buckner Cave (near Bloomington, IN; 45 miles from Indianapolis) during the rescue of a person with serious back injuries in February, 1987.

Army-surplus field telephones connected the cave entrance to the patient's location, through 600 feet of crawlway. **Dwight Hazen** (WB9TLH), an experienced caver, supervised communications at the request of rescue coordinator **Don Paquette** (WB9TLI). Hazen manned the entrance telephone, and used a handheld 2-meter FM transciever to communicate via the K9OK autopatch repeater 8 miles away.

Dr. Sloan wished to consult a neurosurgeon at Methodist Hospital in Indianapolis. Hazen connected his Icom IC-02AT transceiver directly to the underground telephone, and called the Bloomington Hospital emergency room via autopatch. The Bloomington E.R. patched the call to Indianapolis via their own landline facilities. Sloan later left the cave and received a call from the neurosurgeon by telephone at the home of cave owner **Richard Blenz.** He used a handheld radio (in simplex operation) to relay instructions to paramedics in the cave, via Hazen's phone patch at the entrance. An additional phone patch could have provided a direct link into the cave from Blenz's phone; such a device was available but had not been packaged with the rescue phone equipment.

Pre-planning pays off.

Cave-rescue telephone equipment for the area is maintained by **Frank Reid** (W9MKV) and stored in garage. Reid and Hazen had set their electronic garage-door openers to the same code, should the equipment be needed in Reid's absence (which was the case).

Reid added radio-patch circuitry (Fig. 1) to a telephone, after recognizing a need for it during a 1984 rescue. Hazen, Paquette and Reid had discussed ways to interconnect communications links, and had conducted experiments during rescue-training exercises. (See SPELEONICS 3.)

Experience Gained

Radios and telephones used in cave rescue should be interconnectable. Phone patches are easily built from inexpensive parts available at Radio Shack[1].

Repeater users should have phone-patch equipment at their home locations, whether or not their repeater is autopatch-equipped. Autopatches which normally restrict toll calls should have an emergency mode allowing long-distance service. Credit-card calls made via radio should, if possible, be entered by DTMF ("Touch-Tone") instead of voice, to help avoid compromising credit card codes.

The 4-layer link required only one radio operator to switch from transmit to recieve. Had the repeater and autopatch been unavailable, a conventional phone patch or "simplex autopatch" at a nearby telephone would have been necessary. **We** are building additional phone-patch devices for handheld and mobile radios, and encouraging other local hams to do likewise.

Handheld radios should have alkaline-cell battery packs for emergency service. Alkalines have much greater capacity than rechargeable cells, and are readily available. (One set of alkaline AA-cells in an IC-02AT lasted an entire 2.5-day rescue in 1985.)

Ham radio, especially the autopatch repeater, is invaluable to cave rescue communications. Operations should be directed by a ham who is also a caver, thus familiar with both worlds. Emergency communication by ham radio is less likely to attract onlookers and news media than is police/fire/ambulance radio traffic.

References:
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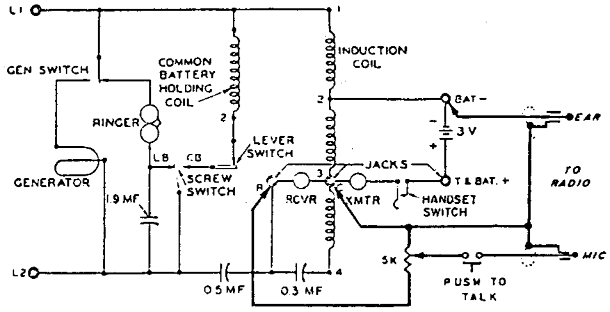
1. Danzer, Paul, "A $10 Phone Patch," 73 Magazine, February 1981, p. 68.

2. War Department Technical Manual TM11-333: Telephones, EE-8, EE-8A and EE-8B, March 1945.



Telephone EE-8—schematic diagram.

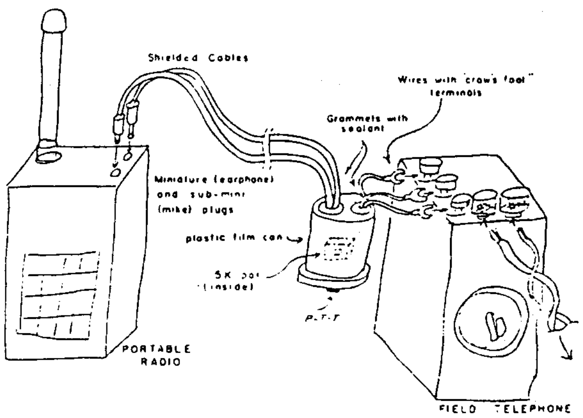


Figure 1. Simple phone-patch (heavy lines) connects EE-8 (World War II-vintage) field telephone to handheld radio transceiver (Icom IC-2AT family). Variable resistor adjusts radio microphone input level. Push-to-talk button and level-control may be housed in a 35-mm film can. Cables to the radio may be several meters long. NOTE: This circuit provides no ground isolation between telephone and radio. It should be used only with self-contained battery-powered radios. [Pictorial diagram by **Gene Harrison.**]

BLOOMINGTON INDIANA GROTTO CAVE-RESCUE COMMUNICATIONS EQUIPMENT CHECKLIST

This list is kept by rescue coordinators and communications specialists. Some of the equipment is kept in a rescue cache; radios and other expensive items are individually owned and amassed when an emergency occurs.

4 Army-surplus field telephones, one equipped with phone-patch for Icom handheld radio transceivers [See SPELEONICS 7].

In "Zip-Loc" plastic bag with each telephone:
- batteries
- pencil
- pencil sharpener
- notebook
- electrical tape
- plastic cable-ties
- instructions
- large plastic trash-bag

1000 m 2-conductor telephone wire (4 spools)

Telephone test equipment:
- Lineman's test set (handheld telephone)
- Tone generator/continuity tester
- Capacitive tone-detector (used with handset and tone gen.)
- Volt-ohmmeter

"Bell-Compatible" telephone with rotary dial
Local telephone directory
Cave-rescue telephone list
ARRL Repeater Directory
Aeronautical sectional chart
List of emergency radio frequencies
Field-phone schematics
Extra microphones for field phones
Electronic telephone-ringer in box w/ terminals
100' telephone wire with modular plugs on ends

Telephone connector adapters:
- Modular : alligator clips
- Modular double-female
- Modular "Y"

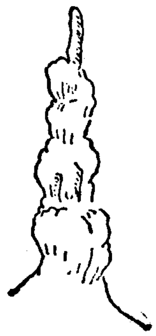
VHF radio transceivers (Icom IC-02AT, IC-04AT, IC-28H; Yaesu FT-23R) modified for extra frequency coverage).

Radio accessories:
- Portable phone-patch device
- Alkaline-cell battery packs w/ spare cells
- "Gain" antennas
- Battery-charging and external-power cables
- Plastic bags/rubber bands (weather protection)
- Neck lanyards
- Speaker-microphone
- Headset
- Repeater components [see SPELEONICS 3]
- 15 m of RG-58/U coax cable w/ BNC connectors
- Assorted RF-connector adapters

Tools:
- Swiss Army knife
- Screwdrivers: flat-blade and Phillips.
- Wire stripper
- Wire cutter
- Pliers
- Nutdriver set
- Electrical tape
- Duct tape
- Felt-tip marker
- Large plastic cable-ties
- Butane-powered soldering iron / fuel and solder
- Large alligator-clip leads (4), 1 m long
- "Slim Jim" tool for opening locked cars

Signal equipment:
- Flare launchers }
- Signal mirror } to mark landing zone for
- Strobe light } helicopter ambulance.
- Smoke bomb }
- Chemical light-sticks
- Surveyors' flagging tape

Flashlight
Rain poncho
Umbrella with antenna mount *
2 pkgs "MRE" military food rations
Plastic canteen
"Heat-tabs"
Waterproof matches
Gloves
Wool cap
Socks (1 pr)



* Do not use in thunderstorms.

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ABSTRACTS
of papers to be presented at 1987 NSS Convention:

IMPROVING THE ORGAN CAVE RADIO

by Ray Cole NSS 12460

Since the initial development of the Organ Cave Radio described in **Speleonics #3** [v.1 #3, Fall 1985], methods of improving the performance while keeping the design simple to duplicate have been examined. One promising technique to improve the performance of the cave radio in noisy environments is to reduce the bandwidth by adding feedback to the first stage to produce a higher effective antenna Q. A design incorporating feedback has been demonstrated on the bench which also provides for full transceive operation with no electrical switching required between transmit and receive. While the autotransformer used in the original design is highly efficient, a slightly different resonant frequency may be present for transmit and receive when using high-Q antennas. This problem can be overcome by using separate primary and secondary windings.

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IMPROVISED TELEPHONES FOR CAVE RESCUE

by Frank Reid NSS 9086

Underground communication is essential when an injured person must be extracted from a cave. The military-surplus field telephones favored by U.S. cave rescuers are increasingly hard to obtain. Several ways to construct inexpensive telephones are described, including a design simple enough to be built in the field in a few minutes, from readily-available components.

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Volume II, No. 3, Winter/Spring 1986-87

SPELEONICS is the quarterly newsletter of the Communication and Electronics Section of the National Speleological Society. Primary interests include cave radio, underground communication and instrumentation, cave rescue communications, cave lighting, and cave-related applications of amateur radio. NSS membership is encouraged but not required.

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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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SPELEONICS
P.O. Box 5283
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USA 47402-5283

Bulk Rate
U. S. Postage
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Bloomington, IN
Permit No. 202