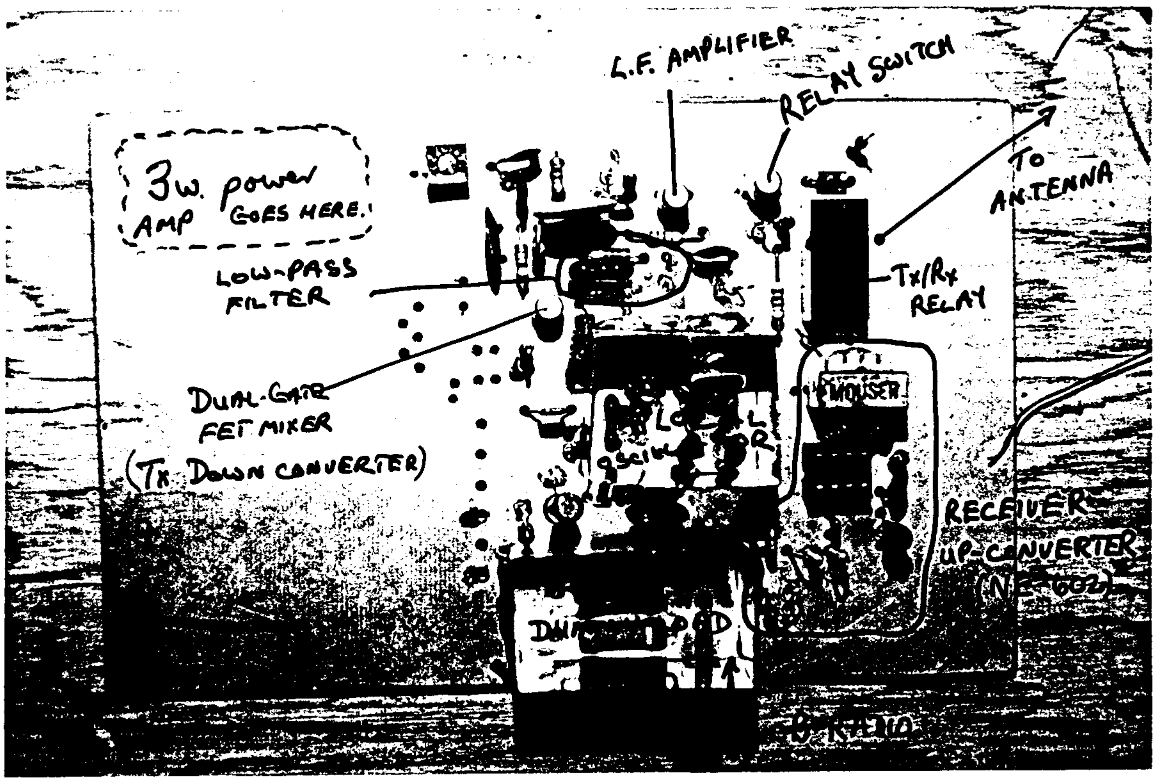
speleonics 19

volume V number 3 MAY 1993



Low-frequency transverter for SSB CB radio makes high-performance cave radio which is easy to build. See article by Ian Drummond.

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SPELEONICS 19

Volume V, Number 3 May, 1993

SPELEONICS is published quarterly (sometimes irregularly) by the Communication and Electronics Section of the National Speleological Society (NSS). Primary interests include cave radio, underground communication and instrumentation, cave-rescue communications, cave lighting, and cave-related applications of amateur radio. NSS membership is not required for newsletter subscription. Section membership, which includes four issues of SPELEONICS, is $6.00 in USA/Canada/Mexico, $8 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 itself. Many members have sent cash without problems. (No foreign currency, please.)

Editorship rotates among the officers. Volunteers are encouraged to guest-edit or produce an issue. A technical session, followed by election of officers, is held annually during the NSS Convention.

Complimentary copies of SPELEONICS go to NSS offices and sections, the U.S. Bureau of Mines, U.S. Geological Survey, and the Longwave Club of America.

Chairman (and editor of issue #20):
Ian Drummond
627 Varsity Est. Cres. N.W.
Calgary, Alberta
CANADA T3B 3C4

Secretary (and editor of issue #21):
Frank Reid W9MKV
P.O. Box 5283
Bloomington, Indiana
47407-5283
internet e-mail:
reid@ucs.indiana.edu

Treasurer (and editor of this issue):
Joe Giddens N5IOZ
PO Box 891
Camden, Arkansas
71701

Printers:
Windy City Underground Press
David & Eleanor Larson
15 S 6th Ave.
La Grange, Illinois
60525

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EDITORIAL

Our frequency of publication has decreased rather drastically for the last few issues. I must take the blame. Although the editorship of SPELEONICS rotates, I usually do the work of assembling each issue and delivering it to the printer. Lifestyles, workloads and priorities change, and our publication has fallen victim to the disease all too common among caving newsletters and other publications produced by volunteer labor. We will discuss the matter at the NSS convention.

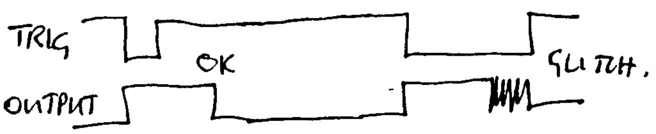
-- **Frank Reid**

LETTERS

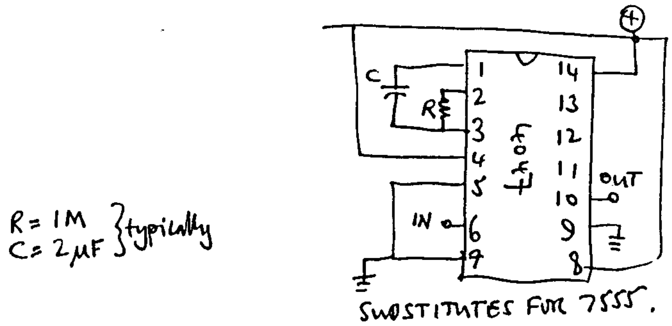
Dear Ian,

I am interested in counting cavers. At the moment we are having a lot of hassle from local residents who are complaining about the number of 'cavers.' We keep logbooks in the 3 main (padlocked) caves and we know that annual figures are about 600, 600 and 1000 respectively because log books are kept in the caves. So it isn't us, as this divides down to not very many per average day. There is a fourth cave (un-gated and no logbook) which is used very heavily by scouts and outdoor pursuits courses. I want to know what the usage level is there relative to 'real cavers' in the other 3 caves.

I saw your 'caver counter' circuit in Speleonics 17 and have tried it both on breadboard and a pcb. It works so long as there is no light on the sensor when the CMOS 555-timed period ends, otherwise you get a bad glitch and a false reading then on the counter. Unfortunately, it is mandatory with 555 timers to condition the input such that the trigger pulse is shorter than the timed period:



You can get around this by substituting a 4047 monostable which does not suffer from the problem. Also by doing this you reduce the quiescent supply current from about 80 uA to 1 uA.



If I have got it wrong somewhere, then perhaps you can let me know, but I feel you must have seen this effect because of the caveats about using a long tube on the sensor, etc. If I am right, then I'll just leave it to you to publish and updated circuit in a future edition.

Yours sincerely,

Stuart France

The Smithy
Tretower
CRICKHOWELL
Powys NP8 1RD
Great Britain

--

Dear Stuart,

Thanks for the upgrade on the "Caver Counter." I was, as you suspected, aware that exposure to a continuous light caused not continuous counting, but collapse of the binary information. I was not aware of the cause of this, and I appreciate your suggestion for fixing it. I have sent the letter on to Frank Reid for his editorial attention. (It's nice to have several editors for Speleonics, not only gives you a rest, but allows some "arm's length dealing" with your own articles!)

The original counter was patched together one week-end as a result of comments in the bar by a Calgary caver doing a master's degree on recreational use of caves in the Rockies (I think!). He tested it fairly extensively in his basement and it spent a month or two, two weeks at a time, in a local cave where it counted a couple of hundred events, a reasonable number when checked against other estimates of visitors. He had plans to build a number of units and check for consistency between units, but I don't think that happened.

Please let me know if you deploy any modified counters. I would be interested to know the results.

Ian Drummond

Dear Frank:

I read with pleasure Speleonics 18, especially the article by Douglas Strait on High-Brightness LEDs. I'd like to add something based on everyday uses of LEDs that are plug-n-play.

Radio Shack has a relatively high output LED, part # 276-086, costing $4.99, which fits (with minimal work) into a Mini-Mag lite flashlite. All that needs to be done is:

1. Unscrew the knurled front end of the flashlight.
2. Remove the small incandescent lamp.
3. Cut the leads of the LED slightly longer than the leads of the incandescent lamp, as you have to approximate the leads of the LED closer together to fit in the two-pronged socket.
4. Insert the LED into the socket (n.b.-the LED is polarized and you have to rotate it to the correct position).
5. Reassemble the flashlight, leaving the plastic parabolic reflector OUT, and you're done!

Calculations, using Radio Shack data, and observed measurements:

Absolute Maximum Ratings

forward current	30mA
forward voltage	2.5V
reverse voltage	4.0V
power dissipation	75.0mW

Electro-Optical Characteristics

forward voltage	1.85V
peak emission	660 nM
luminous intensity	5000mCD

Approximate battery life of two AA nicads (500 mA-hours @ 1.2V) with the regular incandescent lamp is 1 hour; with the LED it ranges from 13 to 17 hours!

Approximate battery life of 2 alkaline AA cells ranges from 22 to 28 hours!

As Doug says in the article, alkaline cells obviously do not have the half-life of lithium cells: the advantage here is that the LED is almost a "drop-in" installation in a standard, unmodified, readily-available, dependable flashlight. This makes its use as "last-ditch" light very accessible.

Dr.Gregory Doria N2SEA
PO Box 280094
Brooklyn NY 11228-0002

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ERRATUM

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In Speleonics 18 the formula on page 2, column 2, line 13 is correct in context but should more properly be written as %capacity = 100% (V-3.00)/3.00.

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NEWS, ANNOUNCEMENTS, RESOURCES

Tom Kaye (NSS News July 1992) suggested that CB channel 2 and 147.48 MHz as "cavers' frequencies." They worked well at the 1992 NSS Convention. **Gene Harrison** (WB4NGC) suggests that caver/hams using VHF or UHF FM transmit a CTCSS frequency so that those equipped with CTCSS decoders can "scan for cavers" while travelling or attending conventions. Gene recommends **203.5** Hz (Motorola PL code M1), a relatively high frequency which will pass through most repeaters.

Continuous Tone Coded Squelch System (CTCSS) is a common way of coding two-way radio gear to allow selective calling of radios in the same organization, or to key repeaters selectively. Units with the same CTCSS code will be able to communicate, others will not be heard.

CTCSS is also known as PL ("Private Line") in Motorola equipment, "Channel Guard" (General Electric), and "Call Guard" in E.F. Johnson gear.

The transmitter generates a tone that is modulated along with the voice signal. The receiver detects the tone and opens the radio's squelch circuitry if the predetermined CTCSS frequency agrees. A high-pass filter removes CTCSS tone from the audio output.

In urban areas and on commercial frequencies there is usually more than one organization on an assigned frequency. CTCSS prevents he separate groups from hearing each others' traffic. If two groups key their radios at the same time and are geographically near each other, they will still cause interference.

--

CAVE RADIO & ELECTRONICS GROUP

BCRA

The Cave Radio & Electronics Group is one of the "special interest" groups of the British Cave Research Association. We publish a quarterly journal of communications, lighting & photography, surveying & computing, and geophysics & cave detection.

Members of the group receive a quarterly *newssheet* containing short articles, news and letters. Additionally members may subscribe to the *journal* which consists of over 20 A4 pages of theoretical and practical articles ranging from electromagnetic theory and cave detection methods to practical advice such as "How to lose the guarantee on your electric drill and related horror stories". Journal 10 includes a practical design for a high performance flashgun slave and a discussion on the design of power amplifiers.

We have also published a bibliography of underground communications containing over 300 references. New subscribers to the journal will receive an index to issues 6-9 listing the Abstract or Introduction to each article. (an index to issues 1-5 is in preparation). Enquiries and subscriptions should be sent to the secretary, David Gibson, at

12 Well House drive, LEEDS, Great Britain, LS8 4BX

- copy of December issue of the journal (#10) £2.50
- Group membership (four quarterly newssheets) £2.50
  membership discount for BCRA members: (£0.90)
- Four quarterly journals (group members only) £5.00
- Bibliography of Underground Communications £5.00
- Other publications and back issues are also available

Prices include airmail postage worldwide. Payment should be in UK currency, by cheque drawn on a British bank, eurocheque, international money order, Visa or Mastercharge accounts. Alternatively you may send cash (US dollars or UK pounds) *at your own risk* (please add 20% to exchange rate). No other currency or credit cards please. Cheques should be made payable to *BCRA Cave Radio & Electronics Group*. If paying by credit card please send a formal authorisation to debit your account, quoting card number and expiry date.

-- Most highly recommended!

Book Review

Prolific writer and philosopher of electronics **Don Lancaster** sent a copy of his newest book, The Incredible Secret Money Machine II, about how to run your own small technical enterprise. It's not a sequel, but an expanded revision, reflecting technology not available when the original was written 15 years ago.

ISMM-II is pure, condensed, useful advice **not available in business schools.** It's available from Synergetics Press, Box 809, Thatcher, Arizona 85552. The International Standard Book Number (ISBN) is 1-882193-65-2.

Having found the publishing establishment increasingly bureaucratic and impenetrable even for one of his track record, Don now publishes and markets his own books. He offers invaluable advice in ISMM-II on doing so, with a discussion of "book on demand" technology.

Don is a caver, NSS member and reader of SPELEONICS.

CONVERTING CB RADIOS FOR USE AS LOW-FREQUENCY CAVE RADIOS

Ian Drummond

Design Philosophy.

Julian Coward and I started building the 3 Alberta Speleological Society (ASS) Cave Radios in 1980, following hand-written circuits from **Pete Hart** in the UK. The radios [described in Speleonics 5] have proved useful, robust, and have generally provided the range necessary for use in the mountains of Western Canada. Unfortunately in the intervening 12 years no-one (including ourselves) has built any further units. Indeed the circuits are daunting, containing many hand-wound inductors requiring individual tuning, and by now several key components are obsolete, requiring redesign work.

There is a demand for Cave Radios; I have been contacted by people interested in using radios for improved communications in rescue work, in scientific studies, in administration of show caves, and in exploration of caves. Why then have no more been built? In talking to people, of the three resources needed (time, knowledge and money) it seems that time is the least available, followed by knowledge, while money is relatively the most abundant resource. (True! Speleonics has carried two adverts from people wishing to buy cave radio systems for cash, yet in talking to people knowledgeable enough to build them, most have preferred to spend their time with their families, caving, or doing something other than building radios in their basements.)

Thus the idea developed to create a cave radio system using where ever possible purchased sub-systems. Various sub-systems were considered, and finally a decision was made to build a system using a CB radio as the central building block. This would be followed by a "transverter" to provide frequency down-conversion on transmission, and up-conversion on reception. A loop antenna and battery would complete the system. A summary of the advantages and disadvantages of such a system was compiled.

I was greatly encouraged in this approach to a cave radio system by an article by **Pat Harrington** intitled "A Simple CB to Low Frequency Transverter" published in Northern Observer #13, October 1989, pp5-11. Pat's article described how he built a transmitter for the 160-190 kHz band, using similar concepts to the ones described here.

Advantages

- A big reduction in construction time.
- Repair services are widely available for CB radios.
- Many people are familiar with CB radio operation.
- The frequency of operation can be easily changed.
- The system can be upgraded and will not readily become obsolete.
- CB radios incorporate features such as squelch and noise-blanking.
- Optimized for 2-way speech communication.
- The known electrical performance of the CB radios provides more consistent performance of the communication system as a whole.
- Allows direct research on the effects of frequency and mode of transmission. [European CB is FM. Some countries also allow AM and SSB. See summary at the end of this article.]

Disadvantages

- The system is electrically inefficient (RF power from the CB is wasted).
- A non-optimum signal processing scheme is used.
- CB radios are not constructed to stand the cave environment.
- The system is awkward for transmission of tone signals.
- The automatic gain control's range and time-constant make null-finding more difficult in location work.
- There is a potential for interference between CB and cave radio frequencies. (Intense CB activity could interfere with a surface cave radio, or cave radio use could leak CB radio transmissions.)

Performance of completed units.

Two complete units have been made, the first by point-to-point wiring on a bread-board with a ground plane (Vector 8004). Building on that experience, a p-c board was etched for the second unit. The frequency and mode (114.28 kHz, upper sideband) was selected to match the ASS Cave Radios. tests in town between the second unit and the ASS radios over the surface gave a range for 2-way speech of 350m [~1150 ft], which exceeded the 300m [~1000 ft] achieved by the ASS radios only.

A similar test in the electrically quieter countryside had easily achieved a range of over 600m [~2000 ft] horizontally on the surface before heavy rain arrived to terminate the experiment.

There is no doubt that the communication was achieved at 114 kHz, not through 27 MHz CB frequency leakage, as the ASS radios are totally insensitive to CB frequencies.

CB leakage was tested by operating a 1.5w CB walkie-talkie (Radio Shack TRC-214) about 20m away. Unfortunately perfect 2-way speech was achieved, despite careful shielding and correct termination of the CB RF circuits. Further work is clearly needed to establish if this is a serious operational problem, both from aspect of CB noise interfering with cave communications, and from reduced security through transmission of cave communications in the the CB bands.

> In summary, these tests indicate that the CB cave radios will perform at least as well if not better than the ASS cave radios for voice communication.

Selection of a CB radio

The CB radio MUST be in a metal case to provide RF shielding. Early experiments using a plastic-case CB walkie-talkie (Radio Shack TRC-214) were terminated when it was found that the unit leaked so much RF radiation through the case when transmitting that it was impossible to make meaningful measurements on a circuit 2m away.

It is strongly recommended that the CB radio be capable of Single Side-Band (SSB) operation. While the cheaper, smaller AM units will certainly work for voice communication, they will be very electrically inefficient, and cannot receive CW (tone) signals for location work. A compromise might be to use a cheap AM unit underground and a SSB unit on the surface. Then the SSB unit can receive the tone needed for location work, and voice contact can be conducted via the AM mode.

The electrical quality of the CB radio certainly affects the performance of the system as a whole. The unit used in the tests mentioned above was a Radio Shack Realistic TRC-453 purchased during a clear-out sale in the USA for US$95.00. (A Uniden(tm) chassis is hiding inside the Realistic(tm) case.)

The most relevant specifications to determine selectivity and sensitivity of the receiver are as follows:

Receiver selectivity - adjacent-channel rejection 70 dB.
Sensitivity for 10 dB S/N, 0.5 microvolts AM, 0.25 uV SSB

Addendum

Since writing the original article, two more transceivers have been built using commercially-produced printed-circuit boards.

The units were matched with antennas tuned to 185 kHz, with the result that CB channel 11 gives the appropriate frequencies. The unit is essentially a 2-channel voice unit, as upper sideband operations covers frequencies from 185.3 kHz to approximately 188 kHz, and lower sideband operation covers 182 to 184.7 kHz. Interferences that are prominent in one sideband are unnoticeable in the other. Unfortunately, I have not been able to devise a simple method of matching the antenna to the transceiver units for a wider variation in frequency.

The PC boards were made by Alberta Printed Circuits who provide a prototype service for small numbers of boards (even numbers, 2 to 12). The cost of two prototype boards (11.4 x 9.5 cm [4.5" x 3.75"]) was approximately $80 Canadian.

One attractive feature of dealing with APC is that they have a bulletin board and it is possible to download "Easytrax" software. Easytrax is a previous generation of professional design software which is fully capable of designing the 2-sided board, with ground information and drill tables that APC need.

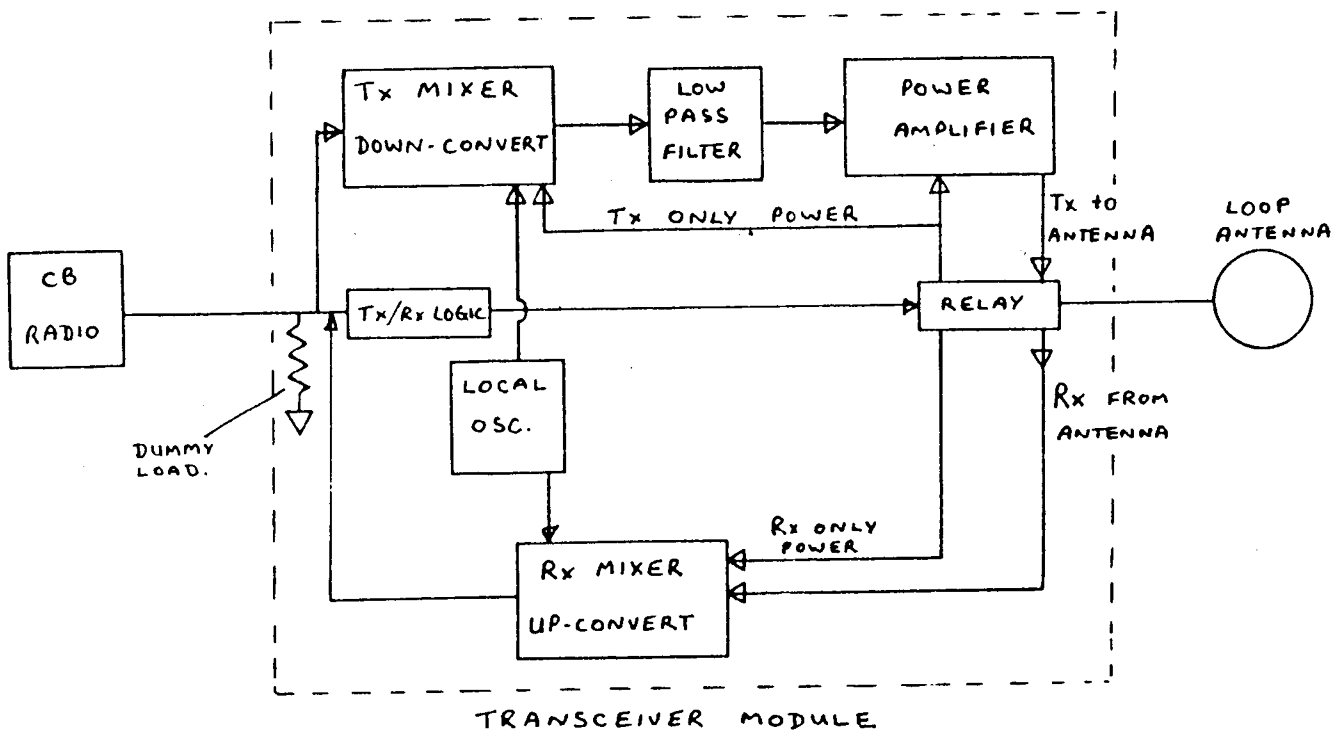
The whole production can be done by modem from a home computer (and not a very fancy unit either; I am running a Tandy 1000 SX with a 20-Meg hard drive and monochrome CGA graphics, but I do have a mouse which is nearly essential for the application). It is possible to download the software, design the board, upload the data files, and have APC make the boards, put them in the mail, and bill your credit card, all by modem over the phone lines.

This software is by far the best deal I was able to locate anywhere in North America. The process is to log-on and download a file called "newuser.exe" which gives all the details needed. Alternatively, they will send the software on a diskette for a $10 handling charge.

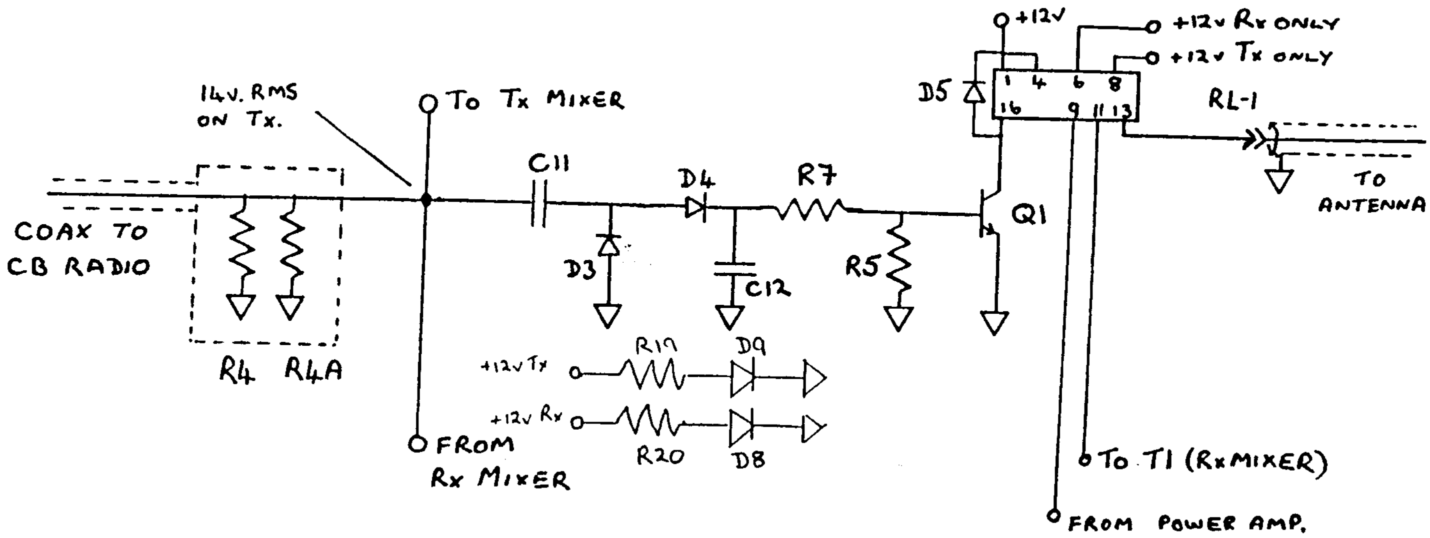
Alberta Printed Circuits, Bay 14, 3650-19 St. NE, CALGARY, Alta
Computer (403 291-9342; voice (403) 250-3406

If you are interested in the PC boards used in this project, send Ian Drummond a letter (address in the front of Speleonics).

BLOCK DIAGRAM

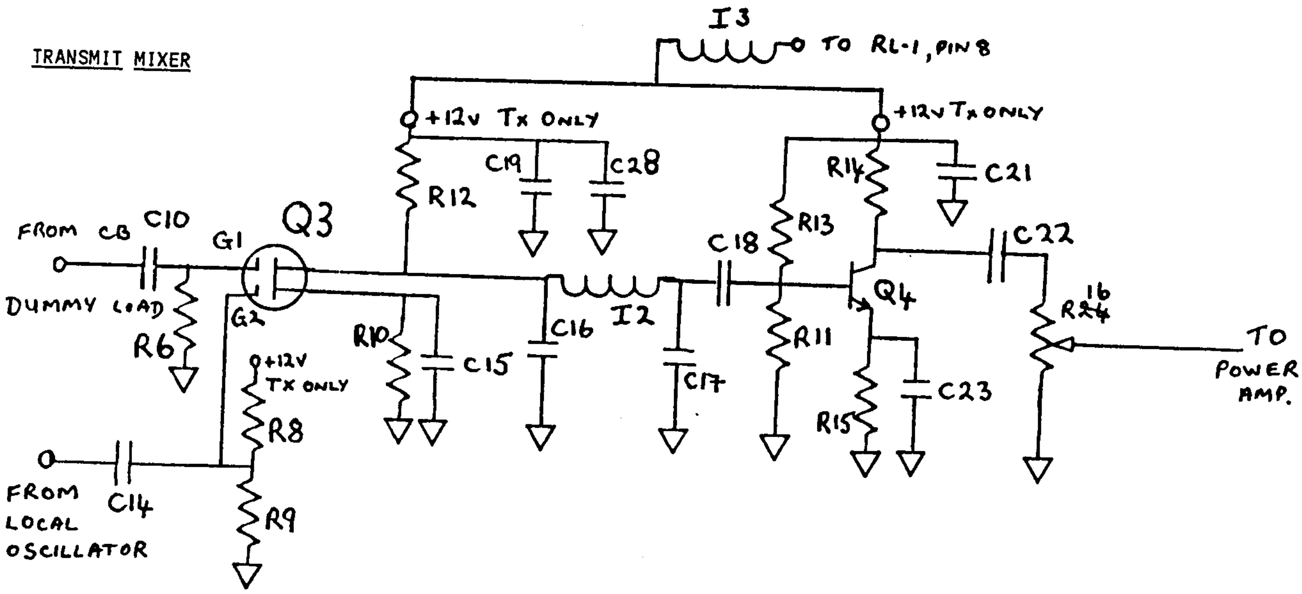


Tx/Rx LOGIC CIRCUITS



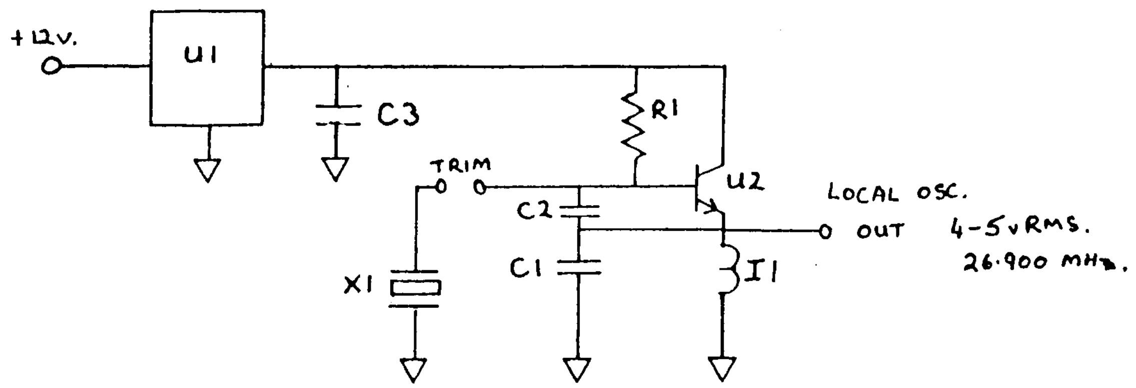
Notes -
1. Adjust C12 to change the 'hang' of the switch after releasing the CB radio transmit switch.
2. Adjust C11 to change the 'attack' of the switch on keying the CB radio.
3. R4 and R4A must present a matched load to the CB radio. Use an SWR meter to check and adjust R4 as necessary.
4. The values given are for a 4w CB transmitter.

TRANSMIT MIXER



Notes -
1. Values are for a 4w CB transmitter. Adjust R6 for other powers.
2. Design is based on 1982 Radio Amateur's Handbook (ARRL), page 8-17.
3. I3 provides power supply isolation from the power amplifier.
4. R12, C16 and 17, I2 and R11 form a low-pass filter with cutoff approx. 500 kHz.

LOCAL OSCILLATOR



Notes - 1. I1/C1 values are critical. Feedback is <1 at fundamental and >1 at 3rd overtone, so X1 resonates at 3rd overtone.

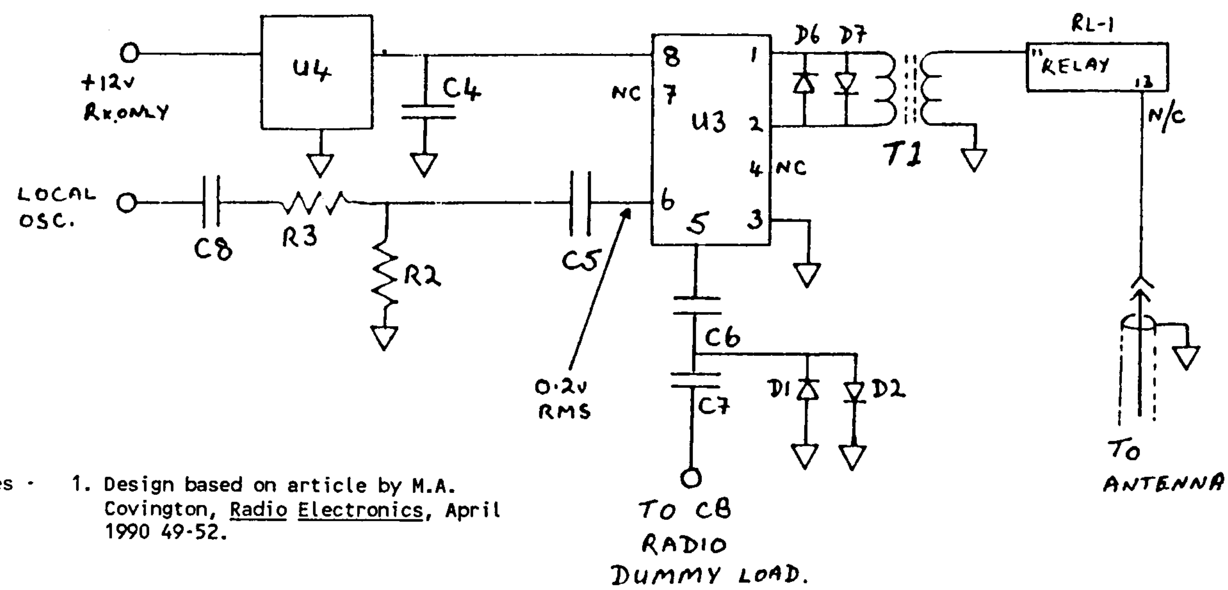
2. U2 must be a high frequency, high gain transistor. Substitutions can significantly change both output voltage and frequency of oscillation.

3. Do not increase the operating voltage, as power dissipation in the crystal could become excessive.

4. Trim = capacitor or inductor to trim frequency up or down (or short).

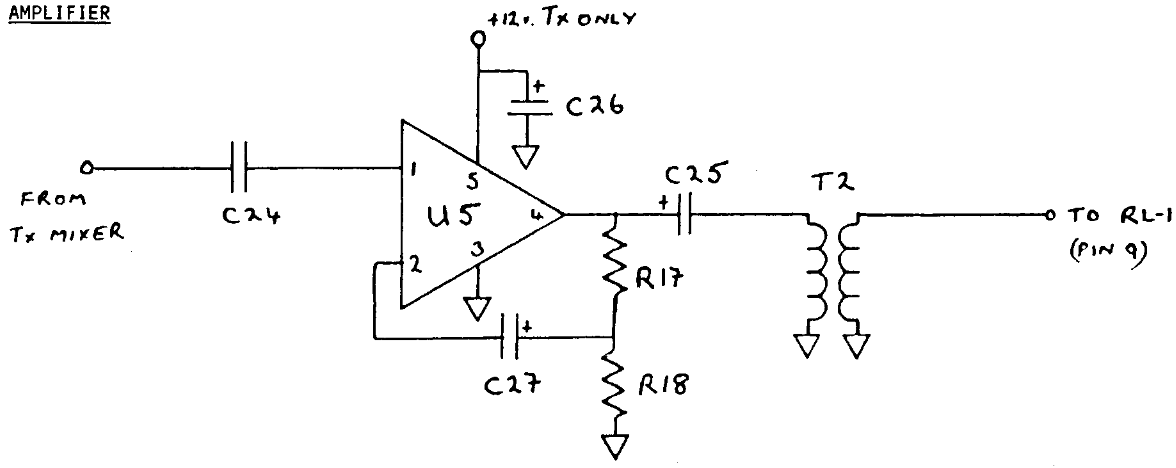
5. Design details from Crystal Oscillator Circuits by R.J. Matthys, Wiley & Sons, 1983. ISBN 0-471-87401-9.

RECEIVER MIXER (up converter)



Notes - 1. Design based on article by M.A. Covington, Radio Electronics, April 1990 49-52.

POWER AMPLIFIER



Notes - 1. Heat sink for 5w needed. Pin 3 is ground and case, so no need to isolate chip from sink electrically.

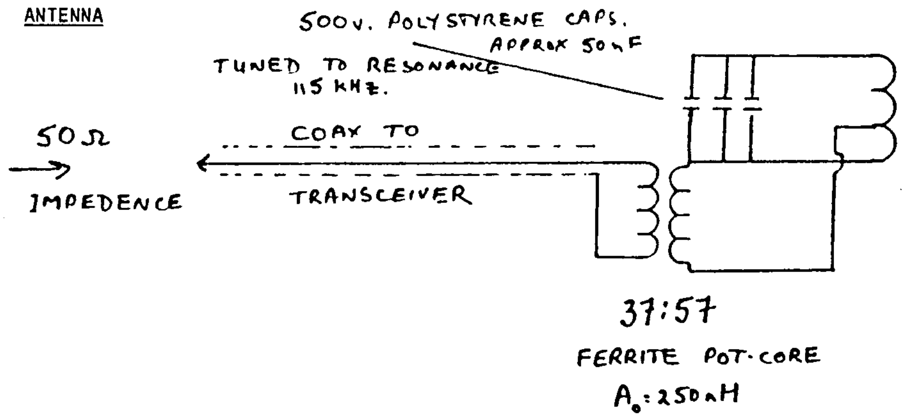
2. TDA2002A provides useful gain to 300 kHz.

3. Power delivered to 50 ohm load is approx. 2.5w.

4. Output at pin 4 cannot exceed 9.5v peak-to-peak.

5. Gain is adjusted by R18. Balance gain in preamp and power amp. to avoid oscillation problems. System is sometimes ok with dummy load but oscillates with antenna connected. Put electronics in metal box to cure!

ANTENNA



Notes - 1. Square frame, 1.42m across diagonal. Coil is 1 turn of 16/3 outdoor cable connected in series to give 3 electrical turns, tapped at 1 turn.

PARTS LIST (PC Board version 92-11-27)

All resistors 1/4 w unless otherwise noted.

R1	120k	
R2	1k	
R3	10k	
R4, R4A	100	2w metal oxide
R5	220k	
R6	5	
R7	10k	
R8	100k	
R9	33k	
R10	680	
R11, R12	3.9k	
R13	18k	
R14	2.2k	
R15	470	
R16	20k	potentiometer
R17	1k	
R18	220	
R19, R20	1k	

C1	36pf	silver mica
C2	1pf	silver mica
C3	1nf	0.1" monolithic ceramic
C4	10nf	0.2" monolithic ceramic
C5	100pf	0.1" monolithic ceramic
C6, C7	5pf	disk ceramic
C8	10pf	0.2" monolithic ceramic
C9		not used on this board
C10	1pf	disk ceramic
C11	24pf	disk ceramic
C12	22uf	35v electrolytic
C13		not used on this board
C14	10pf	0.2" monolithic ceramic
C15	10nf	0.2" monolithic ceramic
C16, C17	220pf	silver mica
C18, C19	10nf	0.2" monolithic ceramic
C20, C21		not used on this board
C22	10nf	0.2" monolithic ceramic
C23, C24	100nf	0.2" monolithic ceramic
C25	470uf	35v electrolytic
C26, C28	220uf	35v electrolytic
C27	100nf	0.2" monolithic ceramic

Trim = Wire jumper (short), a silver mica cap. (0 - 10pf) or inductor (0 - 3uH) to trim the crystal oscillator frequency to desired value.

X1 CB channel 35 Rx crystal (26.900 MHz, 3rd overtone)
R1 Omron G6A-274P-ST-US (DPDT telecommunications relay)
Fuse, 3A picofuse
T1 Mouser 42TL004 transformer (200:8 Ohms)
T2 12:60 turns 26AWG wound on 18mm pot-core (A_1=250 nH) [26AWG = 0.455mm diameter.]
I1 2.2uH inductor
I2 1000uH inductor
I3 470uh inductor
U1 78L05 (5v 0.1A voltage regulator)
U2 MPS6531 transistor (high frequency oscillator)
U3 NE602 (double balanced mixer)
U4 78L06 (6v 0.1A voltage regulator)
U5 TDA 2002A audio amplifier
Q1 2N2222A general-purpose NPN transistor
Q2 not used on this board
Q3 3N211 or NTE 454 dual-gate FET mixer
Q4 2N2222A general-purpose NPN transistor
D1 - D4 1N4148TA (175v 0.1A signal diodes)
D5 1N4004TR (1A diode)
D6, D7 1N4148TA (175v 0.1A signal diodes)
D8 Red LED
D9 Green LED

RF connector to CB radio (male PL-259 and 50 Ohm coax)
CB power cord with in-line fuse (Radio Shack 21-550)
Switch (front panel, subminiature)
BNC female bulkhead connector
Molex 2-pin polarised battery connector
Cable header (PC board connections)
Box (Hammond 1411LO)
Sheet tin for shielding

2-sided printed circuit board (ground plane), produced as a prototype by Alberta Printed Circuits, Calgary.

Antenna Parts List
4m 16/3 outdoor wiring
Plastic Box (Radio Shack 270-222)
BNC male connector
2m 50-Ohm coax
Pot-core, Amidon 1811-77 (A_1 = 2250nH) (wind to match impedance of antenna to 50 Ohm output of transverter).
Capacitors, 630v polystyrene (At least 4 in parallel to tune the antenna to resonance at the operating frequency.)
Self-fusing rubber tape and heat-shrink tubing to splice loop.
Silicone conformal coating.
Wood, to form hub and struts. (Finish with several coats of urethane to water proof.)
--

CB Radio Worldwide - a brief summary

"CB" (Citizens' Band) radio is so named because it is intended to be 2-way radio which anyone can use. Many countries (including the former USSR) now allow 27M-Hz CB as a minimally-regulated set of channels for short-range communications. There are also UHF citizens' bands.

USA: A license is no longer required to operate CB radio in the USA. Legal CB transmitters use AM (4 watts maximum power) or single sideband (12w max) on the following channel-numbered frequencies:

Ch.	MHz						
1	26.965	11	27.085	21	27.215	31	27.315
2	26.975	12	27.105	22	27.225	32	27.325
3	26.985	13	27.115	23	27.255*	33	27.335
4	27.005	14	27.125	24	27.235*	34	27.345
5	27.015	15	27.135	25	27.245*	35	27.355
6	27.025	16	27.155	26	27.265	36	27.365
7	27.035	17	27.165	27	27.275	37	27.375
8	27.055	18	27.175	28	27.285	38	27.385
9	27.065	19	27.185	29	27.295	39	27.395
10	27.075	20	27.205	30	27.305	40	27.405

* Channels 23-25 are not in ascending order for historical reasons. CB originally had only 23 channels. Later, 24 and 25 filled a gap between 22 and 23, and 26-40 were added in ascending order.

Canada: Frequencies, modulation, power same as USA.
United Kingdom: A license is required in the UK. AM and SSB are not allowed.
26.965 - 27.405 FM 40 ch. same as USA. 4w max.
27.6 - 27.99 FM 40 ch. 10kHz spacing. 4w max.
Australia: License is required; there is no examination. Frequencies, modulation and power are the same as in USA. Made-for-USA CB radios are legal in Australia.
France: License required, no examination. France uses the same frequencies as USA but allows FM in addition to AM and SSB. Max power: 1w AM, 4w SSB, 4w FM.
Germany: License required. AM and FM are the only legal modes of modulation; SSB is not allowed. 40 channels, same as USA. Max power: 1w AM, 4w FM. FM is allowed on all 40 channels. AM is allowed only on channels 4-15.
The European CEPT conference: These countries have implemented the Conference of European Postal and Telecommunications administrations (CEPT) recommendations T/R 20-02 and T/R 20-07 for CB radios:

Austria, Belgium, Cyprus (pending), Denmark, Finland, France, Germany, Luxembourg, Netherlands, Portugal, Norway, Sweden, United Kingdom, and Vatican City.

26.965 - 27.405 FM 40 ch, same as USA. 4w max.

With certain exceptions, CEPT-approved radios from any of the countries listed above can be used in any other on the list. If you travel to another CEPT-conforming country, you may use CB under the terms of your license from your own country. **Only FM is CEPT-approved;** AM and SSB may not be legal to use upon crossing borders.

CEPT-approved CB radios are NOT legal in the USA and made-for-USA CB radios are not legal anywhere in Europe.
Japan: No license required. 26.968 - 27.144 AM (no SSB), maximum power 0.5w. Some channels are assigned to fishing vessels (1w max). As in Europe, made-for-USA CB radios are illegal in Japan. Such radios have caused interference with maritime emergency traffic.
Other countries have variations on the CB theme. See references:

1. Popular Communications magazine, Sept. 1992, p59.
2. File PART2 available via anonymous ftp from pit-manager.mit.edu /pub/usenet/news.answers/cb-radio-faq

FURTHER DEVELOPMENTS WITH THE CB TRANSVERTERS

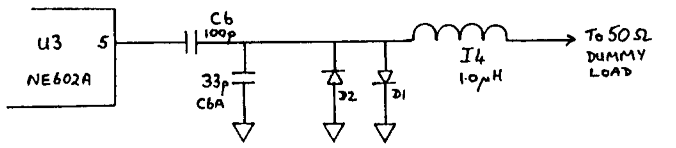
Ian Drummond

A significant improvement to the up-conversion circuit.

During tests at Rats Nest Cave in Alberta, I was surprised to find that while underground in a very quiet electrical environment, connecting and disconnecting the antenna (1 m square, 3 turns) made no difference to the noise which was heard from the CB radio. This meant that the electrical noise from the radio circuits was much stronger than the atmospheric electrical noise. In turn this suggested that a larger antenna would improve the signal to noise ratio at the receiver.

I was surprised by this observation as the CB radio claims that an input of only 0.25 microvolts is needed (SSB mode) to give a S/N ratio of 10 dB. I had thought (without any serious calculation) that there would be more chance of overloading the CB radio receiver than of presenting too weak a signal. Consequently I had deliberately mismatched the output of the NE602A mixer to the dummy load. The mismatch was intended to prevent high voltages burning out the NE602A when the CB radio was transmitting.

Given that the range of the cave radio during the Rats Nest test was being limited by the magnitude of the received signal (and not by atmospheric noise), I revisited the design of this piece of circuit and made the changes shown below. I4 and C6A constitute an L-network matching the 1500-Ohm output impedance of the NE602A to the 25-Ohm impedance of the dummy load in parallel with the CB radio input. (C6A could be made a variable capacitor, so the circuit could be "tweaked" for maximum response). When the CB radio is transmitting, the diodes D1 and D2 conduct, shorting C6A and creating a mismatch to prevent the burnout of the NE602A.



Testing the transverter after this modification indicated that a signal injected into the transverter was only 1/8 of the voltage for the same S-meter reading on the CB radio; a gain of 18 dB! Tests in the cave were even more impressive with the range being nearly doubled. We were able to use 2-way speech (SSB) to 280 m using the 1m antennas, and to 170 m using the 28 x 43 cm (11 x 17") antenna wound into the lid of the carrying case.

I should mention that in town the higher electrical noise means that the signal strength from the 1 m antenna gives an S-meter reading of S-9. Clearly this is close to the largest antenna that could be used in these conditions.

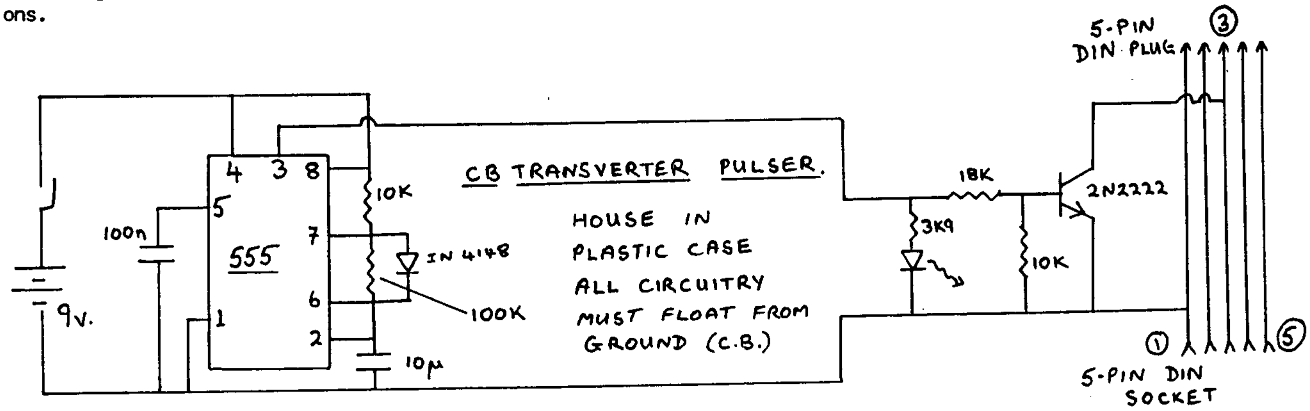
A "Pulser" for transmitting tone signals.

To use a CB transverter system for location work, it is necessary that the underground unit operate in the AM mode and transmit pure carrier, and the surface unit be operated in SSB mode so that the carrier can be detected. The underground unit should also be pulsed, or turned on and off at about once per second, for several reasons. The pulsed tone is easier to detect on the surface, pulsing reduces energy consumption to as little as 10% of continuous operation, and a CB radio is not designed to stand transmission of continuous carrier.

It is possible to pulse the CB radio in the AM mode automatically by an electronic microphone "key" which plugs in between the microphone and the CB chassis. When the unit is "Off/Normal" the CB radio behaves as if the pulser were not present and can be used for 2-way speech in any mode. On turning the pulser "ON", the CB radio switches from receive to transmit for 0.1 seconds every 1 second. If the transverter has been constructed with values as shown (Speleonics 19), the Tx/Rx switch "hangs" for more than a second to accommodate pauses in speech when operating in the SSB mode. Consequently when the pulser is in use, the transverter will stay in the Tx state all the time. This is not an electronic problem, but it does mean that no one can contact the underground unit while they are transmitting tone. If you would like "break-in" operation whereby the underground radio can receive between pulses, the value of C12 in the transverter should be reduced to 10 or even 4.7 uF.

The circuit shown here was designed to work with a Radio Shack SSB CB radio. Other makes will have different microphone plugs, and perhaps even different functional pin connections.

It is worth mentioning here that the transverter system can be used effectively for location work. There have been suggestions that systems which have automatic gain control cannot be used to find nulls in the magnetic field. In my experience the nulls are deep enough that the signal strength falls below the range of the AGC ability to compensate. My feeling is that in the cases where nulls could not be found, the problem is likely to have been the secondary magnetic fields from currents induced in the earth. (see Speleonics 17, Magnetic Moments #5, The Phase Problem).



QUARTZ-HALOGEN CAVE LIGHT

Anmar Mirza N9ISY

Camps Gulf Cave in Tennessee has some of the largest rooms east of the Mississippi River. My normal caving light of twin HPR-50 (5.2v .85A quartz-halogen), while very bright, didn't seem nearly enough light. One day while looking for parts at the local Radio Slack, I found a 12 volt, 20 watt QH (Quartz Halogen) bulb (RS part number 272-1177, rated 350 lumens, 2000-hour life). The price was even better, $1.99. These have a bi-pin base, and are fairly small. I figured they'd fit in my Justrite headpiece, so I bought them and soldered them into an E-10 threaded base where they friction-fit pretty well. A 12V, 15 Ah gel-cell was the power source. Initial tests in a local cave proved the light output to be substantial. What really worried me was how well the Justrite head would stand the heat. The whole metal headpiece got very warm to the touch, and the glass got too warm to hold, but seemed to reach an equilibrium.

Thusly armed, I went to Camps Gulf. I set out with twin 20-watt QHs on the helmet, and a normal HPR50 in a hand-held spot configuration. I was able to light up the rooms spectacularly. Routefinding was no problem. Comparisons with the HPR50 showed no contest. I would not have wanted to attempt routefinding with the HPR50 in this cave! An aside: The Hewlett-Packard ultra-bright amber LED was used as a beacon, and was quite visible from across the room.

ELECTRIC CAVER-HEATER VERSUS CHEMICAL HEAT-PACKS

Anmar Mirza N9ISY EMT-D

Extensive research into hypothermia in relation to caving led me to experiment with various methods of thermogenesis, primarily chemical heat-packs. Each type has advantages and disadvantages. Sodium-acetate packs (rechargeable in the field by boiling in water) work under wet conditions but they dump their heat quickly. They are relatively bulky and heavy for their heat content, and are not very robust. Iron-oxidation packs (non-rechargeable) are lightweight, small, have high heat output, but do not work well when wet. Lying under my electric blanket started me thinking that electrical heat production has many advantages: It can be stopped and started as needed, it's impervious to water, and it can be applied site-specifically. Many electric cavers carry plenty of battery power, and when one is injured, light becomes a secondary consideration to battling hypothermia, at least in caves with temperatures below the mid-60s (F) [~22C].

I scavenged an old electric blanket and removed its resistance wire (about 100 feet [30m]). About 8 feet [2.4m] draws 500mA from a four-D-Cell NiCd pack (my normal battery). Resistance is roughly 10 ohms, about 1.25 ohm/foot [4 ohms/m]. Soldering a connector to the resistance wire was easy, and viola -- an instant electric heater! My connector included 5 feet [1.5m] of 20-ga [0.912mm] wire for ease of placement.

The first test indicated that the heat output of the resistance wire coiled together was roughly that of a small iron-oxidization pack. Calculations proved a little different: Power is roughly 2.5 watts with 100% conversion to heat. Heat output of an iron-oxidization pack is about 40 kcal (46.5 watt-hr) over its 8-hour life, or about 5 kcal/hour (5.8 watts). The electric heater puts out about 2.15 kcal/hour. [1 kcal/hr = 1.16222 watt.]

Heat output could be increased by lowering the resistance but that causes the wire to get dangerously hot. It seems much better to use multiple wires in parallel than to attempt to increase the current through a single wire.

My four-D-cell pack uses 4-Ah NiCds, for a charge life of ~8 hours (20 w-h). Alkaline D-cells would provide about 20 hours (60 w-h), with declining heat output toward the end. Initial output from alkaline cells would be about 3 watts. The heater itself has negligible weight and gives me a spare connector for my lamp or battery pack should their connectors fail. Volume is very small, especially if it is already packed on the body. The resistance wire is highly flexible, so should be easy to incorporate into clothing.

Ed note: Small sources of heat such as those mentioned in the above article cannot re-warm a cave-rescue patient, but they prevent further heat loss and provide significant psychological benefit. Anmar's long paper on hypothermia and chemical heat-packs is available from Frank Reid for SASE, or from Frank or Anmar by e-mail from reid@ucs.indiana.edu or amirza@ucs.indiana.edu

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AMPLIFIER HANDSET ENHANCES CAVE-RESCUE TELEPHONE

Frank Reid

Functions of the National Cave Rescue Commission (NCRC) include development and evaluation of special equipment.

Sound-powered telephones (e.g., U.S. Army TA-1/PT; see SPELEONICS 17) are preferred for underground use because they are considerably smaller and lighter than battery-powered types (EE-8, TA-43/PT, TA-312/PT). Although compatible with battery-powered phones, the TA-1's audio is somewhat weaker, especially when multiple phones are connected to the line. Noisy conditions can make make speech difficult to understand.

The final mock-rescue exercise of the 1992 week-long NCRC seminar was held at Wyandotte Cave, Indiana. Over 3000 feet (1 km) of wire were deployed. EE-8 phones were used at the entrance and staging area/command post, and as many as three TA-1's were active in the cave.

The EE-8 at the staging area had been equipped with a modular handset-jack so that an additional handset or headset could be connected in parallel with the fixed handset. A telephone with two receivers is desirable for rescue staging-areas: A headset is more comfortable for long sessions, and frees the operator's hands. The handset can be given to other people who need direct conversation, while the operator continues to monitors all traffic and keep a log. The disadvantage is that the earphone signals are 3 dB weaker.

Western Electric and other manufacturers make handsets with earphone amplifiers and volume controls. These are intended for noisy environments and for people with hearing problems. I connected an amplifier handset to the EE-8 at the staging area/command post. Signals from the cave became very loud.

Although not mechanically interchangeable, TA-1 earphones and microphones are electrically equivalent. If one transducer fails, conversation can continue by talking and listening through the remaining transducer. Earphones of battery-powered (carbon microphone) telephones also work as weak sound-powered transducers.

The TA-1 earphones in the cave picked up background conversations. The surface operator could advance the volume control to listen-in at will. Volume-control setting was reduced during direct conversations. Having the cave thus "bugged" and hearing the action as it happened allowed people on the surface to gain better understanding of the situation. Staging-area telephone operator **Julia Smith** reported that she heard important details that underground telephone operators failed to mention. An inexperienced or excited underground operator who failed to push the talk button was still clearly audible. The amplifier keeps the surface operator from getting bored. Julia held the handset to her ear almost continuously during the 12-hour rescue exercise.

The amplifier is powered by microphone bias current, and works with the 3-volt field phone battery. The amplifier is an ingenious and unusual circuit using parallel NPN and PNP transistors in a configuration which accepts any power-supply polarity.

Rescue-communications specialists should look for amplifier handsets at hamfests and other sources of surplus electronics. Several amplifier designs are available. A Pacific Plantronics lightweight headset with earphone amplifier has also been tested and works satisfactorily at 3 volts. Its simulated-carbon microphone (electromagnetic mike with amplifier) also works at 3v. The amplifiers are integrated circuits of unknown type.

In the NCRC tests with the unmodified amplifier-handset, the microphone was active continuously. Microphone and amplifier current total 18 mA. Alkaline D-cells should last for more than a month of continuous service.

Although the handset was equipped with a "confidencer" noise-cancelling microphone, an underground phone user reported that it introduced undesirable staging-area background noise into the line. The amplifier's power leads are in parallel with the microphone. The amplifier is unaffected if the microphone is removed. I have added a push-to-talk switch in series with the microphone. Doing so requires cutting a trace on the amplifier printed-circuit board. There is room for the pushbutton in the volume-control panel, located in the front center of the handset.

Holding a handset for a long time is tiring. Substituting lightweight "Walkman"-style earphones for the telephone earpiece was unsuccessful: Their impedance (30-40 ohms) is too low, even if both earphones are connected in series. Telephone earphone impedance is about 250 ohms.

"Modular" telephone connectors, remarkably reliable despite their delicate appearance, are marginally caveworthy. They are easily cleaned if they become muddy, but cannot be replaced without special tools.

Wyandotte is a commercial cave and tours were being conducted during the rescue exercise. When the commercial lights were on, 60Hz hum was audible (though not detrimental to communications) through the amplifier although the line was twisted pair and did not use ground as a conductor. Rescues rarely occur in commercial caves, but hum might limit the amplification that could be used with a single-wire/ground telephone circuit.

PIEZOELECTRIC SOUND-POWERED PHONE IMPROVED

Frank Reid

As noted in Speleonics 18 (p.11), a piezoelectric transducer (Radio Shack part number 273-091, $2.49) can be used alone as a sound-powered telephone which is compatible with military field phones. It is so small and inexpensive that many can be deployed in kits of cave-rescue equipment and carried by individual cavers. One caver suggested attaching a transducer to the outside of each reel of telephone wire, so that it is active while the wire is being deployed.

The problem in each case is protecting the transducer from the cave environment. The round green-plastic container for Skoal(tm) "smokeless tobacco" will hold a transducer and wires terminated by miniature alligator clips. Containers for "tapeworm" bubble gum are identical but are bright pink.

I glued a transducer to the bottom of such a container. With the lid on and taped around the perimeter, the assembly is waterproof. Durable miniature-test-lead wires replace the delicate originals, and pass through holes in the transducer's plastic rim for strain relief. There is a shock hazard if the transducer is against your ear when someone cranks a phone. I insulated the outer side of the transducer with a disc of fiberglass window-screen.

The original model worked poorly. Then I discovered that acoustic insulation around and behind the transducer makes it significantly louder and improves its low-frequency response. It is important to absorb sound coming from the back side of the transducer. **Ammar Mirza** produced a design using a strip of closed-cell door-insualtion tape around the edge of the transducer, filling the space between transducer and container. He used a soldering iron to melt a groove in the foam, which holds the rim of the transducer. A disk of thin wet-suit material in the botom of the container further improved performance.

Piezo phones have been tested underground during several rescue-training exercises. In some, the entrance phone was an EE-8 with amplified handset. Underground users appreciate the light weight but, as with other improvised phones, the lack of a ring-generator and ringer is inconvenient.

Experiments continue: A piezoelectric phone works better with a TA-1 than with another piezo phone. The piezo transducer is electrically capacitive; a carefully-selected shunt resistance to provide a dc path may improve performance.

A neon bulb (NE-2) and series resistor (about 100k), connected across the line, makes a visual "ringer" effective underground but not bright enough for daytime use on the surface. It should be possible to use the capacitive transducer as an audible ringer in a neon relaxation-oscillator operating at many times the 15Hz telephone-ringing frequency.

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WHEAT LAMP(tm) CHARGER NOTES

Frank Reid

AC-powered Wheat Lamp charger models 1577, 1578 and 5301 are internally similar, differing only in the headpiece connectors:

```
             diode            150 ohms,
115    |‾‾‾)|(—|<—gnd         1/2 watt.
VAC    |   )|(                /\/\/\/\            positive
       |   )|(  inductor      |        |    +     batt term.
=D=====|   )|(—()()()—(CB)—o—/ o—o—(A)———————————O-+
       |   )|(  5.25 mH  ckt.bkr.   Hi/Lo   ammeter
       |   )|(                      switch  (2A)
       |___)|(—|<—gnd
             diode
```

gnd = chassis ground, also negative battery terminal.

Transformer secondary voltage is about 12 volts, center-tapped. Old models have selenium rectifiers (metal plates 5 cm square) attached to the case for heat dissipation; newer ones have 3-amp silicon diodes. The High/Low charge-rate switch connects a 150-ohm resistor in series with the battery for low-current "trickle charge" (about 150 mA).

All parts in the charger are very robust with the possible exception of the circuit breaker (2.2A holding current, 3.25A trip; a standard type, easily replaced). Very old chargers have no circuit breakers.

Wheat Lamp chargers are rather expensive, considering their contents. It's economical to build your own, or restore an old one if the connector and meter are still good. **Ray Cole's** linear-regulator circuit first appeared in DC Speleograph (newsletter of D.C. Grotto) in June, 1978. It has been widely reprinted in grotto newsletters, Speleo Digest, and SPELEONICS 6 (Fall 1986).

Linear voltage-regulators used for charging 4-volt batteries from 12-volt sources are inefficient, wasting as heat twice as much energy as they put into the 4v battery. The waste is of little consequence in normal caving, but could result in dead batteries in "expedition" vehicles which sit idle during days or weeks of caving. **Doug Strait** solved the efficiency problem with his switching-regulator charger circuit, published in SPELEONICS 18.

Koehler Corp. (maker of Wheat Lamps) sells a mobile charger which is simply a car tail-light bulb in series with the battery, providing about 1-amp charging current.

Lead-acid batteries need constant-voltage charging, where the current decreases as full charge is reached; a small constant current is then used for "trickle charge" to offset internal losses. Koehler's lightbulb circuit described above is nonideal because it is a constant-current charger; it should not be used exclusively, but it's certainly better than nothing: Lead-acid batteries MUST be recharged as soon as possible after use, else they will deteriorate and lose capacity. It's a good idea to begin recharging in the car on the way home from the cave. At $65+ for a new battery, it is worthwhile to take good care of them. (Nickel-cadmium batteries won't be harmed by storage in discharged state).

"Gel-cells" are electrically equivalent to lead-acid wet cells; two gel-cells in series may be used with a Wheat headpiece, and charged with a Wheat charger, if you can't afford a new Wheat battery. Gel-cells are inexpensive and leakproof, but are physically larger than wet cells of equivalent capacity; Wheat Lamp batteries are rated at 14 ampere-hours.

Ray Cole's charger circuit uses an LM317 adjustable voltage-regulator integrated circuit. Its output is set at 5.2 volts for high charge rate. **Don Paquette** (WB9TLI) has built a field-expedient mobile Wheat Lamp charger from an LM7805 5-volt non-adjustable "3-terminal" voltage regulator (available from Radio Shack). The 7805 is self-protected against overheating and shorted output: It automatically limits current (1 amp) when a discharged battery is connected, then provides constant voltage as charge accumulates.

The 7805 looks like a flat plastic power-transistor:

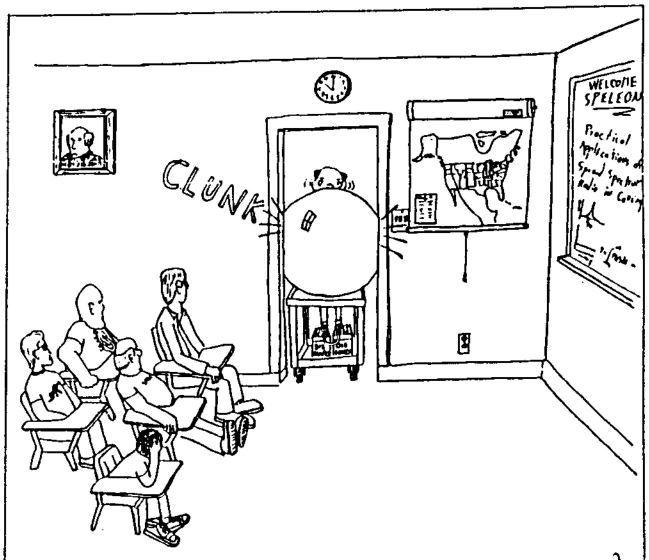
```
              ________________
             |                |
             |       O        |  <--- Bolt the metal tab to
             |================|       a LARGE heat-sink.
             |      7805      |
             |  (front view)  |
             |                |
              --|----|----|--
      input     |    |    |   output
                |    G    |   middle terminal grounded
                |    |    |
+12v ---(^)-----o----|<---o-------> +5.0 volts to
      light     protective          Wheat Lamp battery
      bulb *    diode (1 amp) *
```

* = Optional components: A suitably-rated lightbulb in series with the regulator would act as a current indicator and dissipate some of the heat that the 7805 would otherwise have to dissipate. A reverse-biased diode across the 7805 will keep it from being damaged in case power is removed with the 4-volt battery still connected.

Replacement label for Wheat Lamp(tm) battery chargers (composite of several versions; actual size):

BRIEF INSTRUCTIONS

1. When battery is placed on charge, be sure charger switch is pushed up to HI rate.
2. When meter pointer enters dark area near end of charge (or stops moving toward dark area in case of high line voltage or an old battery), switch to LO for trickle rate.
3. Lamp may safely be left on charge on LO until required for use again.
4. When charged battery is on LO, add water to maintain electrolyte level at Liquid Level Line.
5. Charger may be equipped with a circuit breaker for protection against a short circuit. If unit fails to charge, press button to reset circuit breaker.



Professor Porter encounters a technical problem as he prepares to demonstrate the first LED with the brilliance of a C cell flashlight

Cartoon by **Dick Vernier** (N9AWV), reprinted by artist's permission from Petroglyph (newsletter of Evansville Metropolitan Grotto), v28 #2, Aug-Dec 1992. This year's NSS Convention Electronics Session will be on Tuesday of convention week, starting at 1PM. Bring your projects!

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