CAVE TO SURFACE COMMUNICATIONS

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Abstract

The reasons for needing a cave to surface communication system are many, including safety, search and rescue, surveying, science, exploration and commentary. Ideally a unit should be lightweight, portable, robust, easy to operate, have adequate range and be able to communicate speech intelligbly in both directions.

The unit described here was designed specifically for use on the 1983 Cocklebiddy Cave expedition. When considering design parameters for a communication system there are many limitations, but in a cave as large as Cocklebiddy these can be less of a restriction.

The unit as used does not meet all the above criteria as an ideal system for all caves, but it worked well in Cocklebiddy Cave, conveying our speech intelligibly with tolerable noise and interference levels.

INTRODUCTION

The communication system to be described was designed specifically for use on the 1983 Cocklebiddy Cave expedition (Allum, 1985). The expedition involved an underground duration of 55 hours, with a base camp at Toad Hall, a large chamber 250m long, 15-20m wide, reaching about 20m above the water level. Toad Hall was the site to set up the Radio Direction Finding (RDF) or electro-magnetic location/communication device, for survey location of Toad Hall relative to the surface and as a communications post. Communication with the surface was required to aid:

1. Co-ordination of support divers to assist with the withdrawal of equipment from the cave.

2. Reassurance of and giving expedition news to the surface party, support divers and media.

3. Better utilisation of our reserve air supplies.

4. Co-ordination of rescue and first aid facilities if needed.

After considering many possible transmission methods, developmental time and facilities available, a system using RDF technology evolved. The following considerations were used to our advantage:

1. A weight of several kilos could be tolerated for the RDF/communication equipment; feather weight compared to the 1,200 kgs of diving gear taken to Toad Hall.

2. The terrain above Toad Hall is flat and relatively free from scrub, which allows for an expedient search for the transmitted signal of the RDF.

3. Both Toad Hall and the terrain above Toad Hall are suitable areas where large aerials can be located.

4. The Nullarbor is relatively free from electro magnetic interference from high voltage power distribution lines etc., allowing high gain receiver circuits to work at low frequency.

EQUIPMENT

An RDF unit (as previously described by Hurst, 1977) was used but modified to reduce transmitter battery drain. The transmitter was operated for 25 minutes 'ON' 5 minutes 'OFF'. This cycle could have been maintained for several hours whilst the search for the signal on the surface was taking place. Toad Hall lay 2.5 km to the north of the last RDF location of the first rockpile chamber.

<u>The modified R.D.F. transmitter</u>

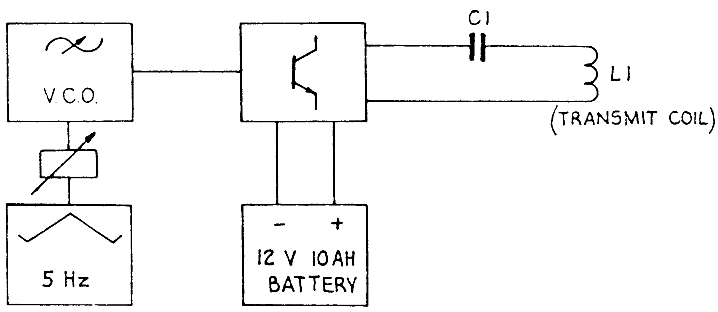

Figure 1. Block diagram of the R.D.F. tramsmitter.

Referring to Figure 1, L1 is the transmitter aerial, a coil of 260 turns of 1.6 mm dia wire on a 300 mm I.D. former. L1 in series with C1 is tuned to a resonant frequency of approx 1.8KHz , by changing the frequency of the oscillator. Current drain from batteries at fR is approximately equal to voltage applied, divided by the series resistance of the resonant circuit, so that approximately 2 amps can be drawn from the 12v supply. Using a triangular shaped wave form derived by charge/discharge curves of a timing capacitor when applied to the voltage controlled oscillator (Figure 2), the frequency is varied so that the tuned circuit can be brought to resonance 10 times per second using the applied 5Hz frequency. Maximum field strength is still obtained at fR giving good output field strength, however reducing battery drain by 80%

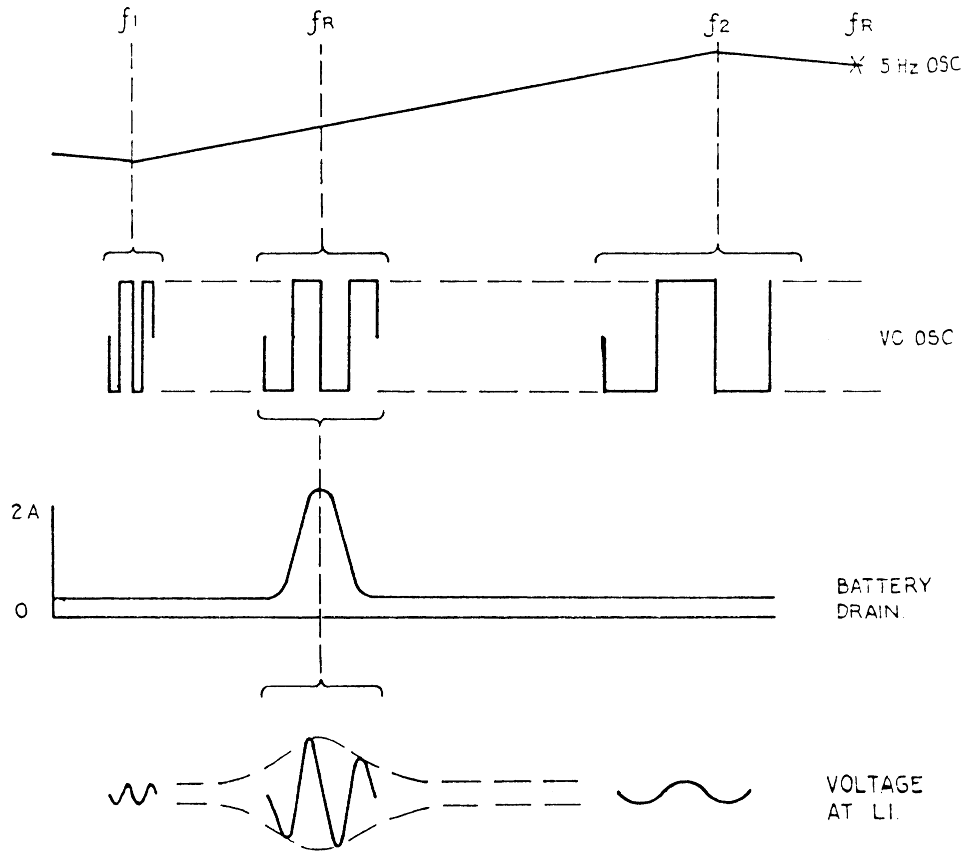

Figure 2. Modulation of the output to reduce battery drain.

Unfortunately the RDF described does not have an adequate band pass to allow transmission of voice frequency.

$$f1 - f2 = \frac{fR}{Q} \qquad Q = \text{gain of L1 at fR} \simeq 60 \text{ times}$$

$$= \frac{1800}{60}$$

$= 30Hz$

or 1,785Hz to 1815Hz

To convey speech intelligibly a band pass of 1 KHz about a fR of 1 KHz was tried successfully. A tuned circuit of unity gain is therefore required.

$$Q = \frac{fR}{f1 - f2}$$

$$= \frac{1000}{1000}$$

$$= 1 \text{ or unity}$$

The electromagnetic voice transmitter

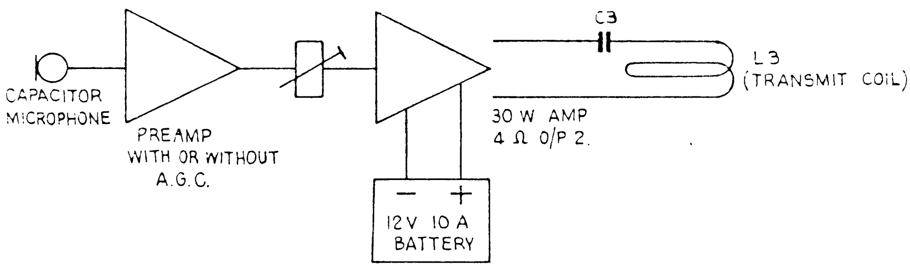

Figure 3. Block diagram of the voice transmitter.

Referring to Figure 3, L3 is the transmitter aerial, a coil consisting of 2 by 100 metre lengths of 1 sq mm insulated building wire to form 2 turns 32 metres diameter. L3, C3 is a tuned circuit, fr approx 1 KHz, f1 - f2 approx 1 KHz. Series resistance at fR > 4 ohms.

A 30w car stereo booster amplifier was divided into 2 amplifiers (one for cave transmitter, other for surface transmitter) and used to drive the tuned circuit. A front end from a cassette recorder having an inbuilt capacitor microphone was used to convert speech to an electrical signal. The circuit used had automatic gain control, which was suitable for the cave transmitter but not desirable for surface transmitter. A preset control allows matching of levels for correct operation of the two amplifier stages.

The R.D.F. receiver

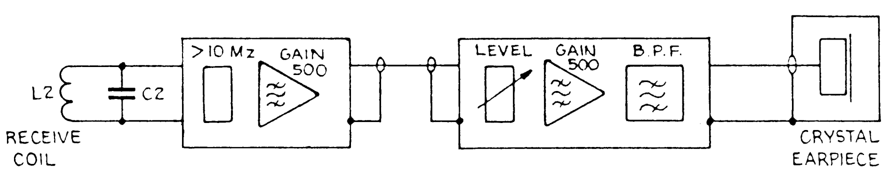

Figure 4. Block diagram of the RDF reciever.

Referring to Figure 4, L2 is the receiver aerial, a coil of 2,200 turns on a 500 mm ID former. L2, C2 is a resonant tuned circuit at 1.8 KHz. The signal is amplified by a high impedance ampliffier then via a level control to another gain stage and a band pass filter. Note shielding through all stages including the crystal earpiece.

The received signal (from the transmitter) is that of a 'Warble" (i.e. 1.8 KHz pulses at a 10 Hz rate).

The electromagnetic voice receiver

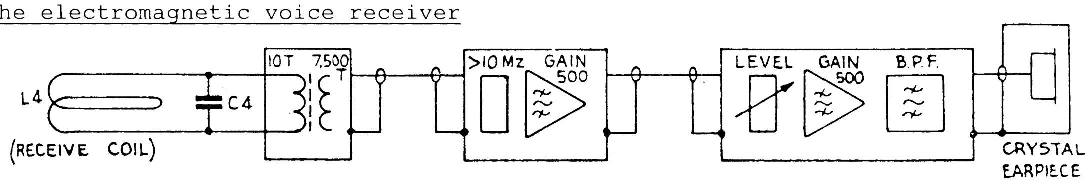

Figure 5. Block diagram of the voice receiver

Referring to Figure 5, L4, C4 are similar components to L3, C3 of the voice transmitter except that they are parallel tuned. Impedance matching is achieved using a transformer (1/P'Z'4 O/P'Z' 2.25M).

Although the amplifier stages appear very similar to the RDF receiver described earlier their high/low roll off frequencies were tailored to the bandwidth of the voice transmitter, 700 Hz to 1.7KHz.

The electro-magnetic transceiver

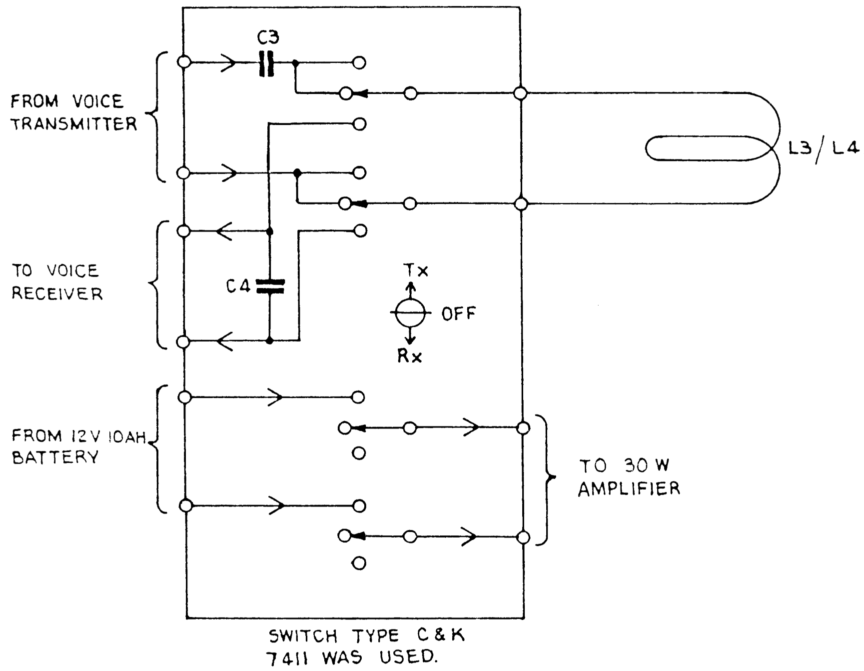

Figure 6. Switching circuit for the transceiver unit. Note: aerial is connected to transmitter in the switch centre position before 12V supply is turned on to transmit.

The switching diagram (Figure 6) shows how the units are combined to share the common aerial. Both cave and surface transceivers are similar. The aerials must be located one above the other (hence the use of RDF to locate the aerial's axis). (Figure 7).

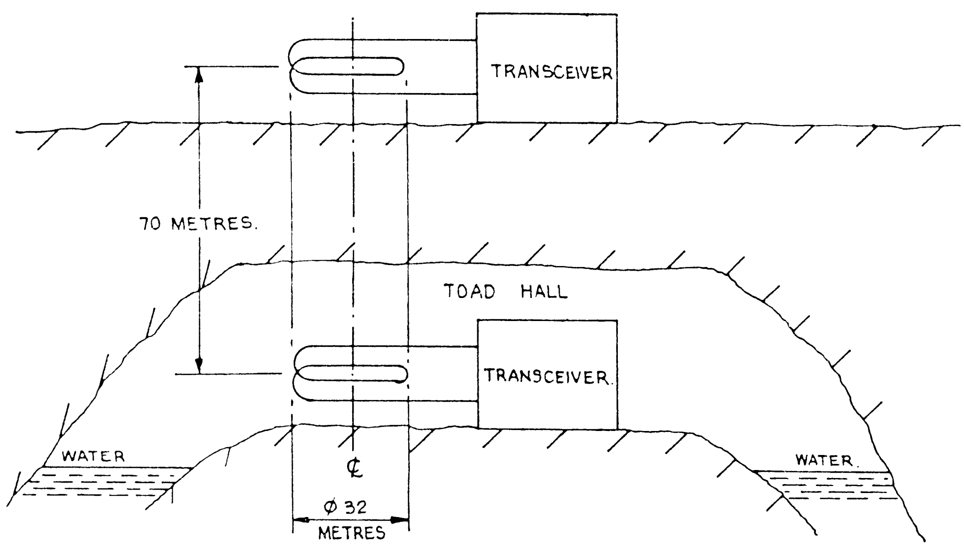

Figure 7. The relationship between the two aerials once radiolocation had succeeded.

The system in use

As previously mentioned a pre-determined switch-on time was made. The RDF transmitter was turned 'ON' for 25 minutes then 'OFF' for 5 minutes. This 'OFF' time was used to establish communications; if not made the cycle was repeated.

The communications system worked very well, however due to limited developmental time and no field measurements it is felt that many improvements can be made. For instance the transmit/receive coils' inductance was never measured but thought to be about 0.6 mH.

From actual use the first receiver amplifier stage had too much gain; the gain control between the two stages had to be near minimum to receive an undistorted signal. The concept of the unit was designed about the close mutual coupling between the two aerials, being derived by large coil diameter (approx. 32 metres) and the relative spacing between (approx. 70 metres) (Figure 7); if developmental time had permitted small diameter coils would have been tried making the unit suitable for other cave requirements.

REFERENCES

ALLUM, R. 1985 Diving at Cocklebiddy Cave. This volume.

HURST, G. 1977 Electromagnetic underground position location. Proc. 11th Bienn. Conf. Aust. Speleo. Fed., Canberra 1976: 74-78.

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