

ATMOSPHERICS MONITOR



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Tune in to the sounds of the heavens in turmoil!

WITH the chaotic weather of recent years, have you given any thought to what's going on up there? It is generally known that you can hear on a domestic radio the electrical activity of lightning when a storm is in progress, with the characteristic large *crack* and *swishing* sound, emanating from the speaker and that's about all.

What if you could hear other sounds over a distance of thousands of miles away, such as *Inter Cloud Discharges*, *Sliding Whistles*, *Tweaks*, *Pings*, *Chirps*, *Risers*, *Chinks*, *Clicks*, and the exotic *Dawn Chorus*?

"Has this guy lost his marbles?" Well, no, because indeed you can detect and monitor all these sounds from our atmosphere, from the comfort of your home, using little more than a ferrite rod with a wideband amplifier, and piezoelectric sounder – as you can now discover!

WHAT IS THIS ACTIVITY?

There are historical accounts linking the earth's ionosphere sounds that go back to the days of early telephone development over long wires. During 19th Century and First World War use, strange sounds emanating from earphones were noted. They became known as Natural Radio, a product of global lightning, producing on average over 44,000 discharges a day.

The most sought after is the elusive Whistler that produces a sliding note, from around 6kHz down to 300Hz, with a duration of between 0.3 and five seconds. This sound is created when a distant lightning strike on the other side of the earth produces a wide spectrum of electrical noise that becomes ducted into the earth's magnetosphere (magnetic field in space). While radiating outward, it combines with the solar wind's ionising charge to create the dispersed and sliding high to low frequency whistle that can be heard with this design in your hemisphere.

Another rarity is the Dawn Chorus, which sounds like a rookery of birds, combining rising whistles, chirping and warbles, produced through the sun ejecting

charged ions that impinge on the earth's magnetosphere, causing the *Northern Lights*, or *Aurora*, seen seasonally from dusk through to dawn in various parts of the northern hemisphere.

Many other short period sounds can be heard like Pings, Hooks, Chirps and Risers; also Chinks and Tweaks. The last two are dampened oscillations from 1.6kHz to 4kHz, throughout the earth's waveguide around the ionosphere's D- and E-layers, 45 to 75 miles above the earth. These create a bell-like resonance that rolls-off sharply around 1.5kHz.

Another sound that can be heard is the Inter-Cloud discharge activity, occurring just as storms build-up, prior to any forked lightning discharges. The excess electrostatic cloud charge reaches its limit, to discharge within the cloud, producing an unusual sound known as "Walking On Broken Glass", variable over a duration of 0.4 to 1.2 seconds.

WHISTLER'S MOTHER?

The experimental years have been long in developing the Atmospherics Monitor described here. The birth of the idea eventually came to maturity as the circuit shown in Fig.1.

The aerial rod and coil assembly, L1, set the radio frequency reception bandwidth. The incoming amplitude modulated signal is initially a.c. coupled to transistor TR1 and op.amp IC1a. Preset VR1 sets the transistor's bias current and thus the half-rail bias voltage (4.5V) for IC1a. Stage gain is principally set to around $\times 28$ by resistors R5 and R6.

The bandwidth of this stage is set by capacitors C2 and C5. The frequency response characteristic at IC1b pin 1 is shown in the top curve in Fig.2. The -1dB knee points are 2.3kHz and 9.1kHz, although as the roll-off continues a greater bandwidth extends until the noise floor is reached at -12.5dB , relating to -63dB or $600\mu\text{V}$.

Part of this noise is generated by transistor TR1, even though a low noise BC109C is used. The atmospheric background is alive and kicking just below this



Resistors

R1, R10 2k2 (2 off)
R2, R16 10k (2 off)
R3 100k
R4 270k
R5, R13 1k (2 off)
R6 27k
R7 150k
R8, R9 220k (2 off)
R11 47k
R12 15k
R14, R15 22k (2 off)
R17 33k
R18, R19 120k (2 off)
R20 5k6

Potentiometers

VR1 47k or 50k min. round preset
VR2 100k rotary carbon

Capacitors

C1, C16 220µ radial elect. 16V (2 off)
C2 10n ceramic disc, 2.5mm pitch
C3, C6, C13, C17 100n ceramic disc 2.5mm pitch (4 off)
C4, C10 2µ2 radial elect, 16V (2 off)
C5, C8 1µ radial elect, 16V (2 off)
C7 220p ceramic disc, 2.5mm pitch
C9 560p ceramic disc, 2.5mm pitch
C11 220n ceramic disc, 2.5mm pitch
C12 820p ceramic disc, 2.5mm pitch
C14 22µ radial elect. 16V
C15 22µ

Semiconductors

D1 to D3 1N4148 signal diode (3 off)
TR1, TR2 BC109C npn transistor (2 off)
IC1, IC2 LM358 dual op.amp (2 off)

Miscellaneous

L1 ferrite rod, 200mm x 10mm dia., plus 500 turns 40s.w.g. enamelled copper wire
ME1 250µA panel meter
WD1 resonant piezo sounder, 4-6kHz

Stripboard, 13 strips x 35 holes; plastic case to suit (optional); furniture "foot" to fit WD1; plastic tube to mount L1 - see text; 9V PP3 battery and clip; knob for VR2; solder, etc.

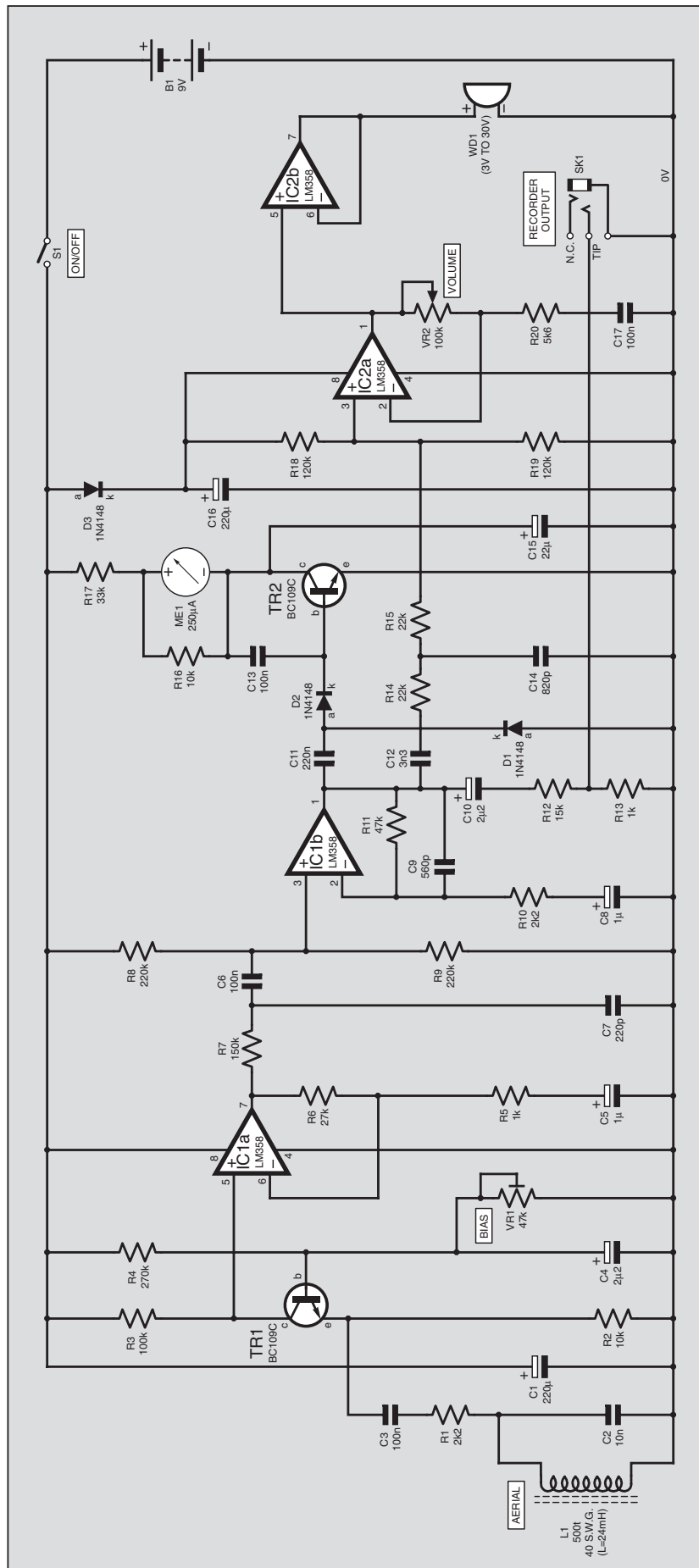


Fig. 1. Complete circuit diagram for the Atmospherics Monitor.

level, and the average activity appears between -11dB and -4dB over a range of 1000 miles, but can peak in times of storms to $+1\text{dB}$ of short duration electrostatic pulses.

The output from IC1a is a.c. coupled to the second stage, around IC1b, where further gain of about $\times 22$ is given, as set by resistors R10 and R11. Capacitor C9 limits the upper frequency response in order to maintain stability.

The output from IC1b is taken in three directions. The first route is to the stage around transistor TR2. The signal is rectified by diodes D1, D2 and capacitor C13, and then amplified by TR2 to drive the $250\mu\text{A}$ meter ME1.

This signal activity meter provides weighted readings of atmospheric discharges. On quiet days the meter pointer will deflect to a quarter of its scale, but can change to half or more of full scale readings as inter-cloud activity builds up. Really frenetic activity will produce full scale deflection. On power-up the meter swings to full scale deflection to indicate good battery condition.

The output from IC1b is also a.c. coupled via capacitor C10 and

attenuated by resistors R12 and R13. This signal is suitable for feeding to the microphone input of a tape recorder.

Thirdly, the output from IC1b feeds via capacitor C12 and resistors R14 and R15 to the audio gain stage provided by IC2a. The gain is set by potentiometer VR2. The output from IC2a is buffered by unity-gain stage IC2b which drives a resonant piezo sounder having 80dB of gain.

Referring again to Fig.2, the lower graphic curve shows the response at the output of IC2b. It has similar characteristics to the upper curve, but has been given a reduced roll-off at 7.3kHz . This is primarily due to the sounder resonating at 4.6kHz , although not very sharply.

A standard loudspeaker was found to be unsuitable in this application, because the induction between the aerial and speaker would cause feedback when the volume was increased. By using a piezo sounder the output's electromagnetic field is kept exceptionally low.

In practice, the amplifier output stage's micro eddy currents are the limiting factor, so the overall gain is set such that soft sounds can just be heard above the background noise, without causing signal feedback.

Power for the circuit can be provided by a 9V PP3 battery.

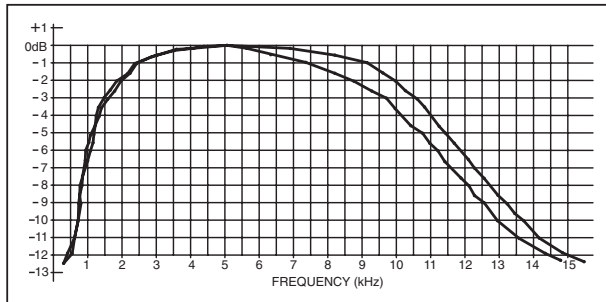
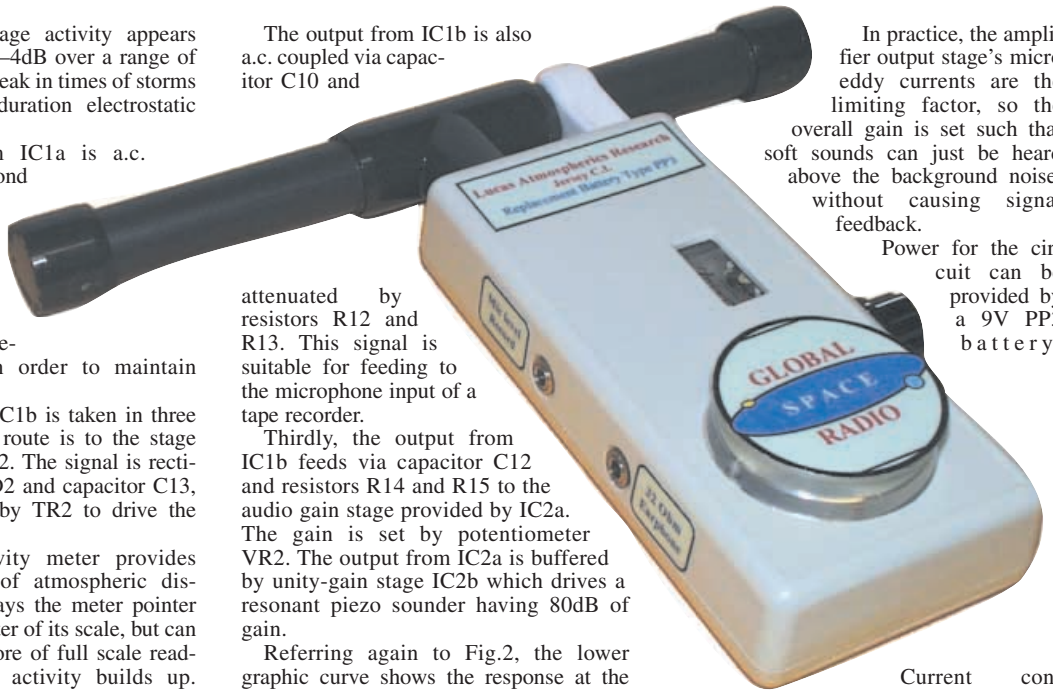


Fig.2. Monitor frequency responses.

Current consumption is about 2mA maximum. The supply is smoothed by capacitor C1 for the stages up to TR2. For the output stage around IC2, the supply is via diode D3, smoothed by capacitor C16. This is to minimise instability in the rest of the circuit from large electromagnetic pulses.

CONSTRUCTION

The Atmospherics Monitor is constructed on stripboard. The component layout and track cut details are shown in Fig.3. Note that some resistors are mounted vertically. Use sockets for both i.c.s. Assemble in order of ascending component size.

The aerial ferrite rod required should be 200mm long by 10mm diameter. The use of two 100mm rods is permissible, but they

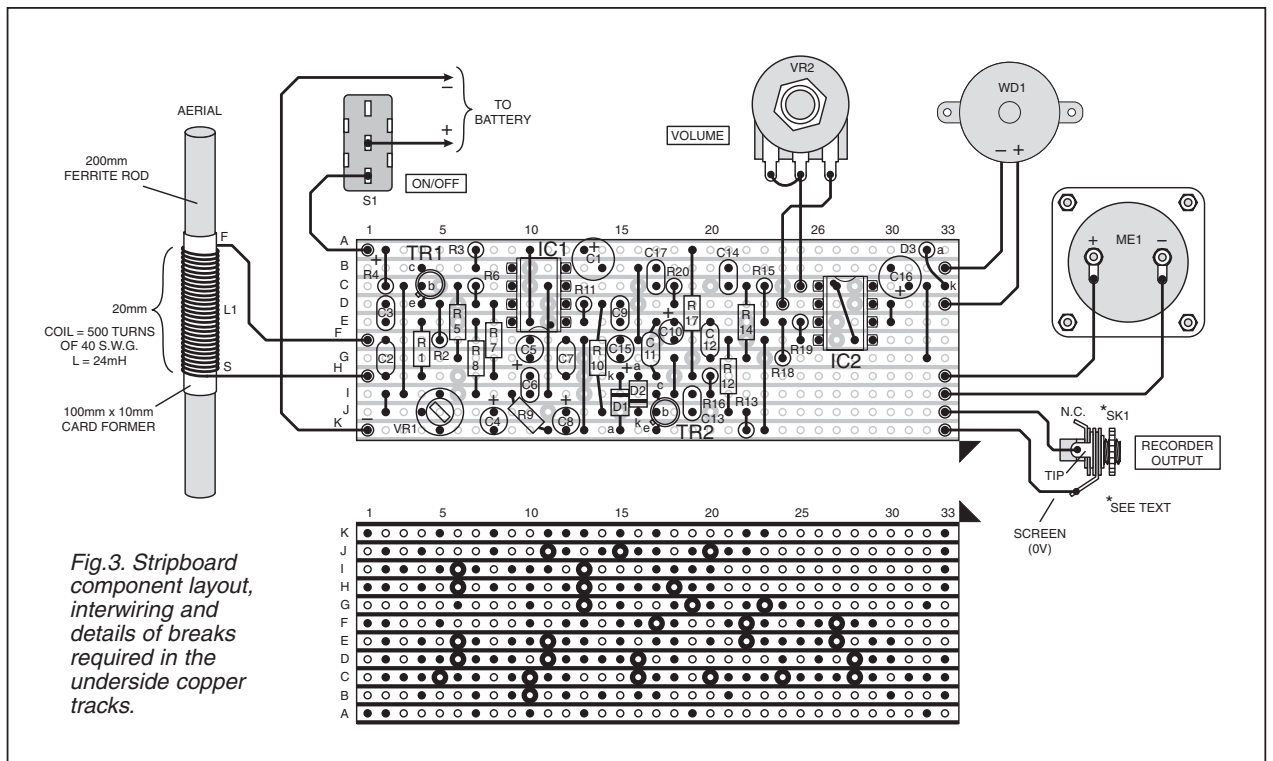


Fig.3. Stripboard component layout, interwiring and details of breaks required in the underside copper tracks.



The translucent "furniture cup" is held in position on the case by the sounder mounting lugs.

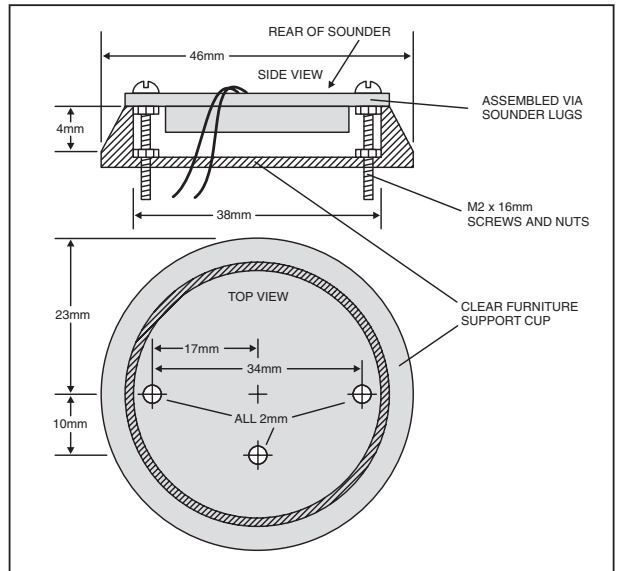


Fig.4. Suggested method of mounting the piezo sounder on the outside of the case.

must be glued end-to-end whilst held under pressure. The coil former should be 100mm in length, formed from thin cardboard into a tube that can be slid tightly over the rod to span its centre.

COIL WINDING AND ASSEMBLY

The coil requires 500 turns of 40s.w.g. enamelled copper wire. This should be wound onto the cardboard former, within a 20mm area, back and forth. It is not necessary to have every coil turn side by side, far more important is that the finished

result has an even coil surface, by filling in gaps with turns as an ongoing process. At the last turn, label this wire as the finished over-winding (marked F in Fig.3), for negative 0V connection to the stripboard. The inductance value is roughly 24mH. Insulating tape can be used to secure the coil turns in position, or use glue.

The rod assembly needs supporting onto resilient mounts, but do not use rubber

case measuring 66mm x 38mm x 140mm, with holes drilled as appropriate.

The aerial was enclosed in a plastic plumbing pipe having an internal diameter of approximately 14mm and a total length of 225mm. The tube was cut and inserted into a plastic "T" junction which was pushed into a hole cut into the case and glued in place. The two ends of the pipe were covered by caps of the same diameter. A plastic pipe clip bolted to the case helps to provide further rigidity of the assembly.

Plastics adhesive bonded the aerial assembly attachments, although this should not be applied until after the unit has been proved to be working correctly.

LISTENING TIMES

Atmospheric activity is primarily East to West, so the aerial rod's length should be aligned with this direction. The period between sunrise and midday tends to be quiet for atmospheric activity. However, from midday to late evening, the clouds and thunderstorms build up through heating and convection, particularly in the summer and autumn months. By sunset the atmospheric activity becomes frenetic, and the Pings, Chirps, Clicks, Hooks and Chinks are likely to be heard.

From midnight to sunrise regular Tweaks and Risers might be heard. Dawn Chorus, as its name suggests, can be heard particularly at sunrise, also other times if Aurora activity is high. Whistlers though, require active solar flare ion bursts via ducting conditions, to produce this sound.

Using the unit indoors, you are likely to encounter interference, mainly from television and computer monitors, but also house wiring to a lesser degree. However, by varying the orientation of the aerial, you can null-out very sharply the majority of unwanted hum and other numerous near-field electromagnetic activity radiated within the home.

The best results come when you are monitoring out of doors in the evening night sky. Moreover, this has its own charm, while you ponder the wonder of our world and the universe beyond the stars! □

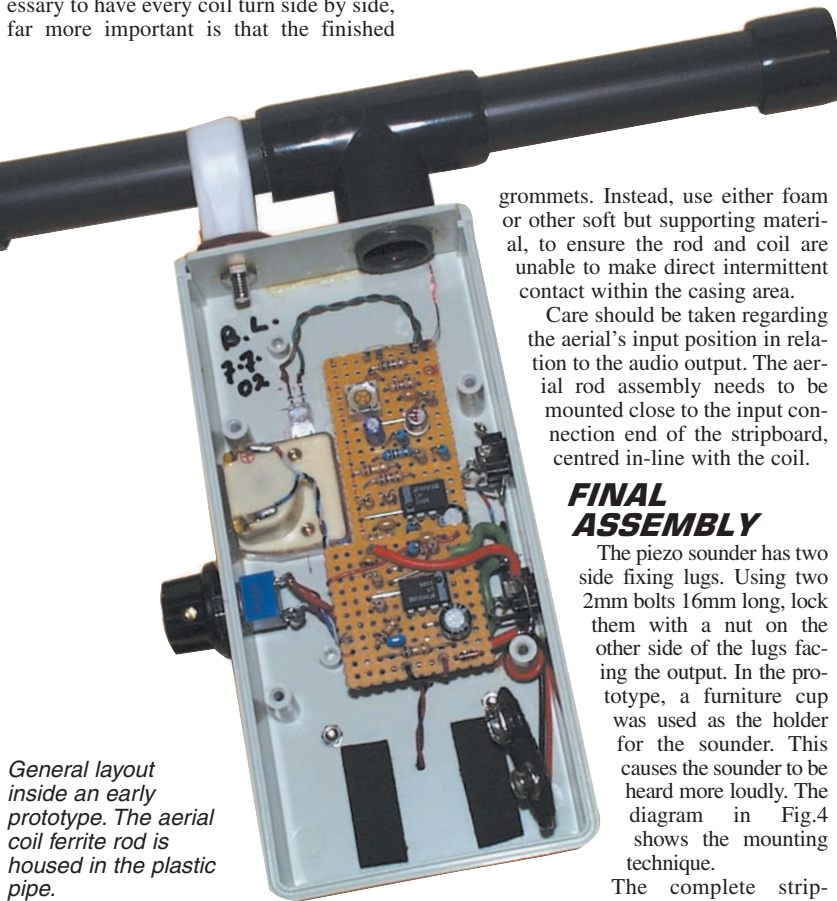
grommets. Instead, use either foam or other soft but supporting material, to ensure the rod and coil are unable to make direct intermittent contact within the casing area.

Care should be taken regarding the aerial's input position in relation to the audio output. The aerial rod assembly needs to be mounted close to the input connection end of the stripboard, centred in-line with the coil.

FINAL ASSEMBLY

The piezo sounder has two side fixing lugs. Using two 2mm bolts 16mm long, lock them with a nut on the other side of the lugs facing the output. In the prototype, a furniture cup was used as the holder for the sounder. This causes the sounder to be heard more loudly. The diagram in Fig.4 shows the mounting technique.

The complete stripboard assembly was mounted in a plastic



General layout inside an early prototype. The aerial coil ferrite rod is housed in the plastic pipe.