Super-Ear Audio Telescope

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Listen more clearly to those distant sounds

SUPER-EAR has been designed to incorporate a home-constructed parabolic element which boosts the sensitivity of an electret microphone for picking up sound at a distance. For example, as utilised in wildlife studies and, dare it be said, for eavesdropping on conversations from afar!

Because the microphone is securely held in copper tubing, impact and vibrational sounds through a barrier can also be detected to a certain extent. It was found with the prototype, that so long as a few precautions are followed, the results are comparable to those from a commercially produced device.

Parabolic Theory

Most readers will be familiar with satellite dish antennas in the shape of a parabola. Whereas a true parabola has a precise mathematical definition, most items approximating to this shape and with a reflective surface can be used to "catch" sound.

As shown in Fig.1, sound waves travelling more or less parallel from a distant source strike or "illuminate" the parabolic element. These in turn are re-directed to a focal point, *X*, at which the microphone is placed. In effect, this captures the targeted audio.

Although the focal point varies with different parabolas, the pick-up power of the microphone is considerably boosted since more sound waves are available from a particular source. The received input signal is then amplified as smoothly as possible by a sensitive circuit.

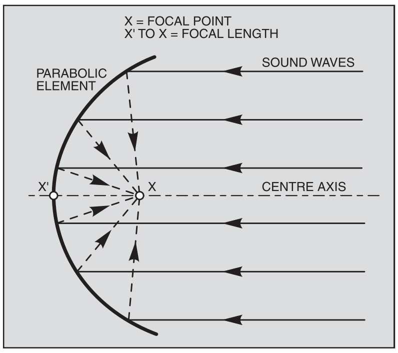


Fig.1. Properties of a true parabola

Circuit Description

In order to adequately amplify the input signal, the circuit consists of both preamplifier and audio amplifier stages. Referring to the full circuit diagram for the Super-Ear Audio Telescope in Fig.2, the electret microphone, MIC1, is powered via resistor R1, which behaves as its load. The signal produced by MIC1 is a.c. coupled via capacitor C1 to the base of *npn* transistor TR1.

The network around TR1 forms the preamplifier stage. Resistors R2 to R5 bias it for linear amplification. The BC109C chosen is ideal for low noise audio applications such as this, offering more than adequate gain, although other general purpose high gain *npn* transistors will work in this design.

Any instability at this stage could distort signal processing throughout, hence the inclusion of capacitors C2 and C4. Capacitor C6 provides thermal compensation in the emitter circuit. Capacitor C3 and resistor R6 decouple the stage from disruptive power supply variations.

Audio Amplifier

Capacitor C5 couples the preamplified signal to level (Volume) control VR1, from where it is fed via C7 to IC1 input pin 3. The circuit around IC1 forms the audio amplifier stage. Capacitor C8 acts as an audio filter and the value quoted can be varied up to several nanofarads.

The LM386N audio amplifier i.c. has been chosen for IC1 because it is relatively easy to use and provides a smooth gain of over 200 (set by capacitor C9).

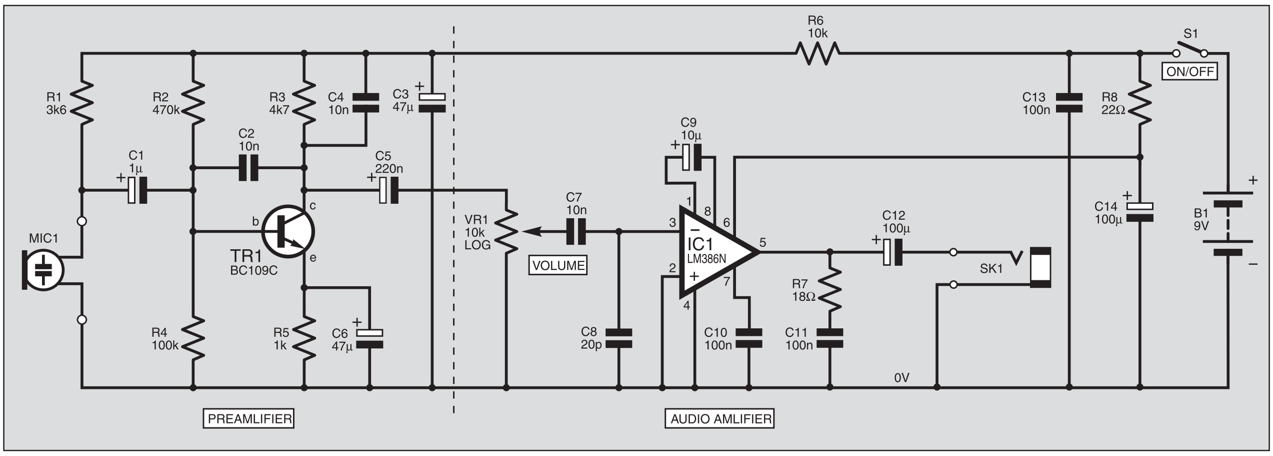


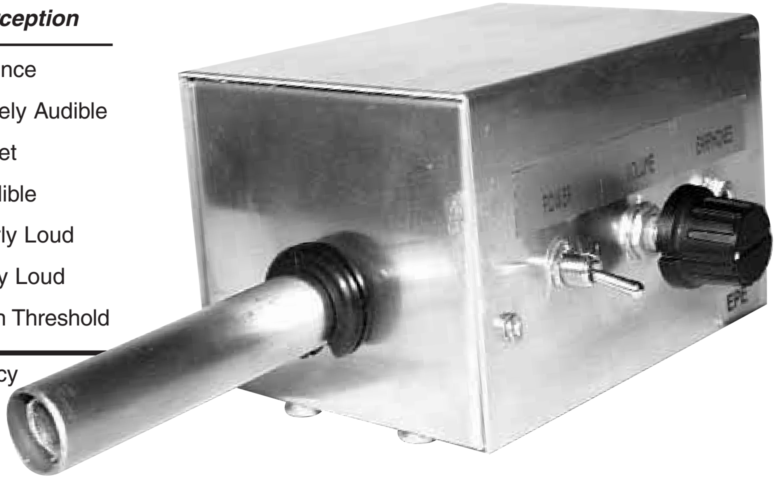
Fig.2. Complete circuit diargam for the Super-Ear Audio Telescope. This circuit is built on two circuit boards; preamplifier and audio amplifier

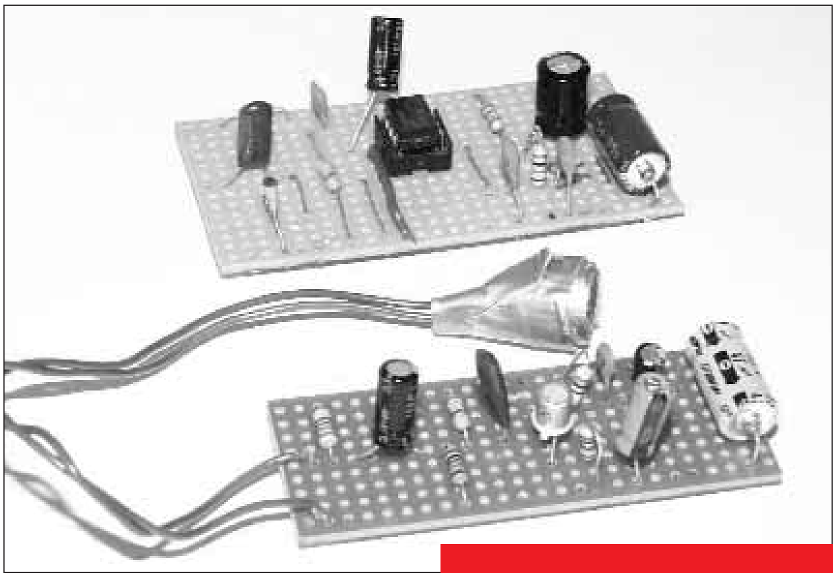
Table 1: Perception of Sound Intensity

Source	*Decibels**	*Perception*
–	0	Silence
Rustling Leaves	10	Barely Audible
Soft Whisper	20	Quiet
Conversation	60	Audible
Factory	80	Fairly Loud
Construction Noise	110	Very Loud
Rock Concert	120	Pain Threshold

* Decibels, perceived level varies with frequency

Note that the human ear tends to perceive higher frequencies more easily





The two prototype circuit boards, with the tape-insulated Mic. between them. Differs slightly from the final unit

Most of the external components for IC1 are needed for stability. Capacitor C13 caters for variations in the supply voltage and is used on the main amplifier board, as opposed to the preamplifier board.

With IC1's output impedance being 64 ohms, Walkman-type headphones are preferable to speakers. This also avoids the problem of "telephony" which can hamper performance.

Construction

The prototype was built on two separate stripboards for several reasons. Firstly, both stages are isolated, which helps minimise problems with spurious feedback, whilst making fault-finding easier. Secondly, because the project is handheld, compactness is an issue. Two smaller circuit boards can be used to make the most of the available space.

The component layouts and track cutting details for the two stripboard assemblies are shown in Fig.3. Assemble the boards in the usual order of ascending component size, having first correctly cut the tracks where required.

Ensure that the electrolytic capacitors and the semiconductors are inserted the correct way round as shown. Use a socket for IC1, but do not insert the i.c. until the assembly has been completed and checked for accuracy.

Note that the electret microphone insert is also a polarised device. Its case is internally connected to one of its pins, to which the 0V connection should be made. The wiring to the microphone should not exceed about 140mm in length.

Testing

The circuit should be fully tested before housing it in a metal case. It is suggested that the main amplifier is tested first, without it being connected to the preamplifier.

When the amplifier is powered, touching the middle lug (wiper) of VR1 (or pin 3 of IC1) should produce a coarse buzz at

COMPONENTS

Resistors

R1	3k6	
R2	470k	**See**
R3	4k7	**SHOP**
R4	100k	**TALK**
R5	1k	**page**
R6	10k	
R7	18Ω	
R8	22Ω	

All 0·25W 5% carbon film or better.

Potentiometer

VR1	10k rotary carbon, log

Capacitors

C1	1µ radial elect. 25V
C2, C7	10n polyester (2 off)
C3	47µ axial elect. 25V
C4	10n ceramic disc
C5	220n radial elect. 25V
C6	47µ radial elect. 25V
C8	20p ceramic disc
C9	10µ radial elect. 25V
C10, C11, C13	100n ceramic disc (3 off)
C12	100µ radial elect. 25V
C14	100µ axial elect. 25V

Semiconductors

TR1	BC109C *npn* transistor
IC1	LM386N audio amplifier i.c.

Miscellaneous

MIC1	electret microphone insert
S1	min s.p.s.t. toggle switch
SK1	3·5mm jack socket
B1	9V battery (PP3 type), with clips

Stripboard 25 holes × 9 strips; stripboard 30 holes × 14 strips; control knob; parabolic dish (see text); metal case (110mm × 75mm × 60mm); copper tubing, standard type, approx. 15mm diameter × 100mm; mounting clip for tubing (see text); nuts and bolts as required; connecting wire; solder pins, solder, etc.

Approx. Cost Guidance Only **£10** *excl batt & hardware* the output. There should also be a low level hum at the output, confirming that the amplifier is working. Once the amplifier has been proved, the preamplifier can be connected to it.

Key test voltages are shown in Table 2 and can be measured with a multimeter. Initially check if the microphone is picking anything up by gently tapping it and hearing the output. The prototype easily picked up ambient sound with VR1 set to less than a quarter of a turn.

Casing It

One problem encountered with circuits such as this is that they can easily pick up electrical interference, including odd (but strangely untraceable!) vibrations.

This was remedied by housing the circuit in a metal case, with the microphone situated in a copper tube (see later). Alternatively, plastic tubing with metal tape wrapped around it will suffice.

Before mounting the boards in the case, first drill the necessary holes in it and secure the copper tubing. As Fig.5 shows, the latter can be attached fairly robustly to the case with the help of a mounting clip as used in plumbing installations.

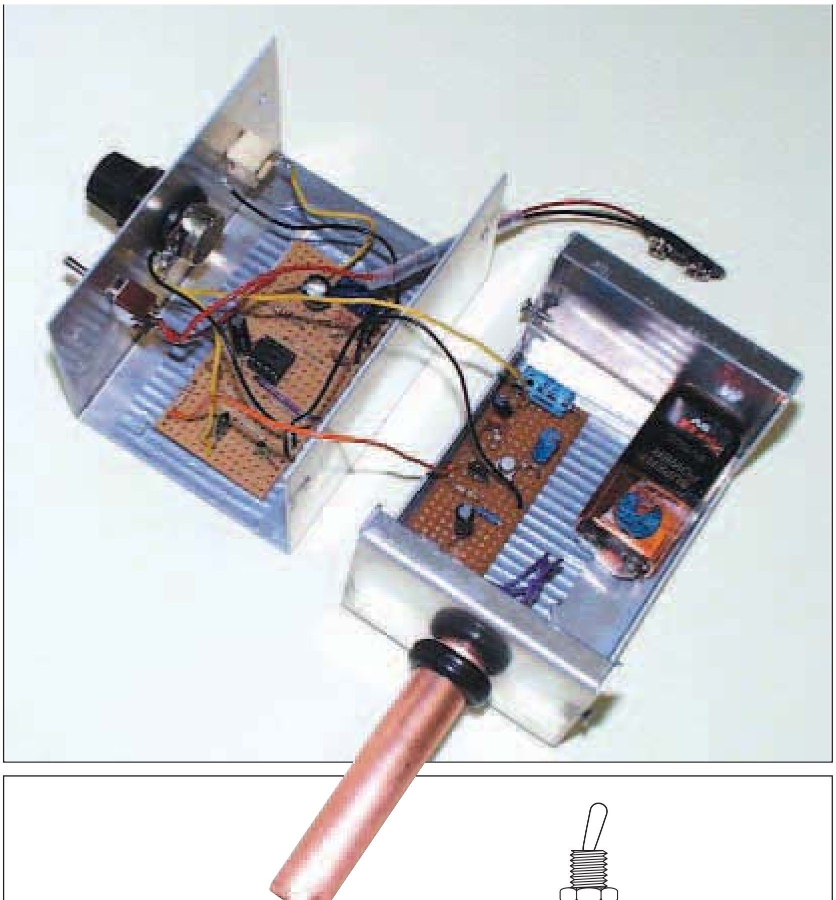
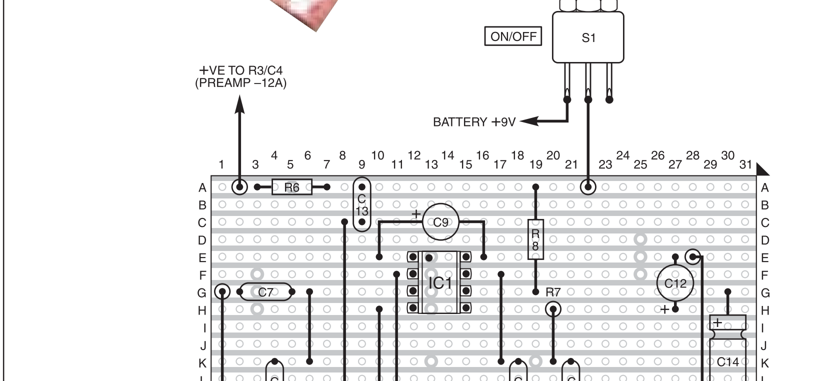


Table 2. Key Test Voltages

Pre-amp supply line	3·8V
Voltage across microphone	3·1V
TR1 base	0·2V
TR1 collector	3·1V
IC1 pin 5	4·5V

Assuming a 9V supply (error ±0·1V)



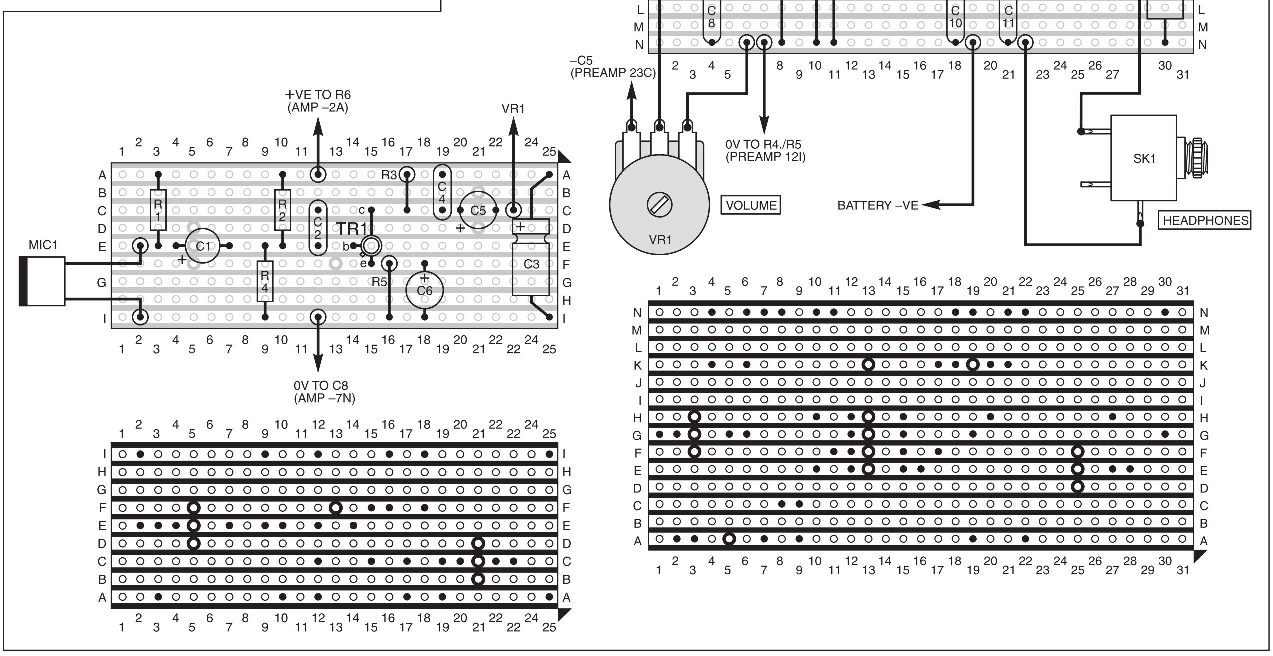


Fig.3. Super-Ear Audio Telescope stripboard component layouts, interwiring and details of breaks required in the copper tracks of the preamplifier and amplifier boards. The wiring and positioning of the two boards within the two-piece aluminium case is shown in the above photograph

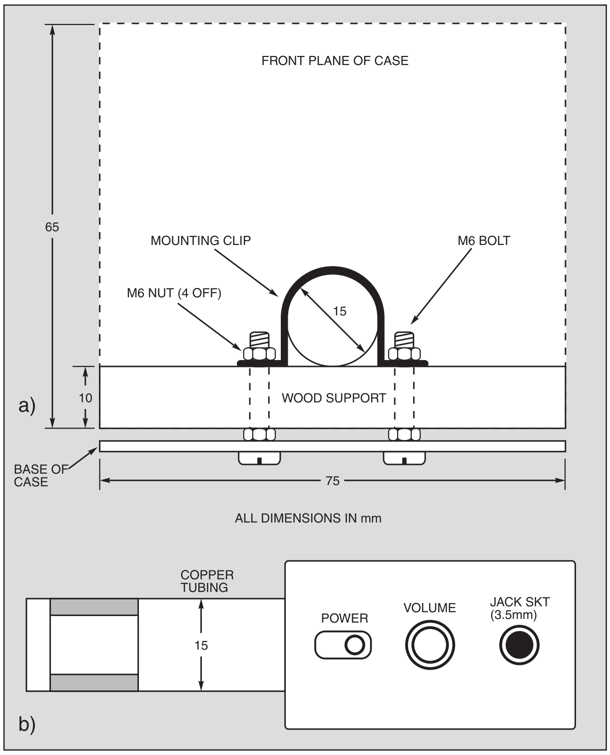


Fig.4. Securing the copper tubing, housing the mic. insert, inside the metal case (a) and (b) position of off-board components on one side panel

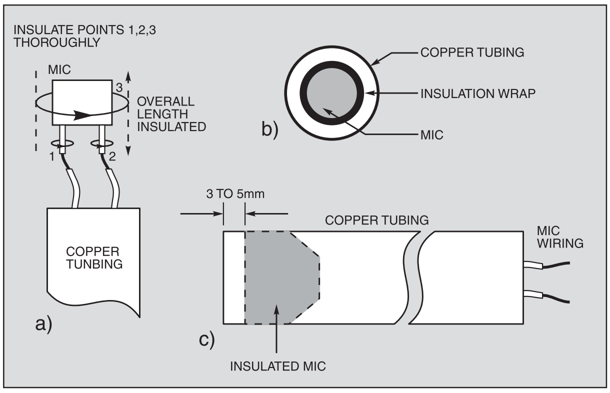


Fig.5. Insulating and wiring the microphone insert (a), end view showing insert "plugged" into the copper pipe (b) and the Mic. insert recessed in the copper tubing (c)

Electret Mounting

Because the circuit is extremely sensitive, anything picked up by the microphone can result in an ear-splitting whine dominating the output. This can be resolved by thoroughly insulating the microphone's bare metal surface using insulating tape. Handle the microphone carefully to avoid damaging its pins. Solder the connecting cable to the pins and, as shown in Fig.5, wrap tape around each of them.

Push the cable through the copper tubing until it emerges from the other end. Now apply further rounds of tape over the microphone's case, leaving the pick-up surface free. The microphone can then be eased into the tubing to around 3mm to 5mm short of the rim. For a snug fit and to prevent loosening, apply further rounds of tape.

Parabolic Matters

As mentioned earlier, almost anything concave and reflective to sound will boost the pick-up power of the microphone, it does not have to be a true parabola. The shape includes items such as aluminium bowls, old style car hub caps, and disused satellite dishes.

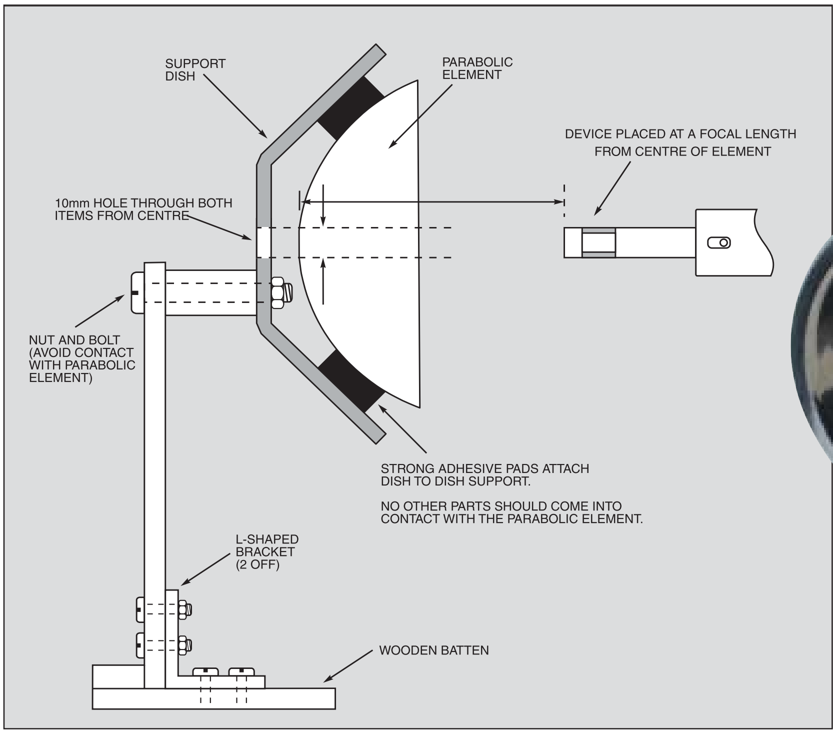


Fig.6. Suggested method for constructing a cradle/support for mounting a bigger more robust parabolic element (dish)

In Use

In use, some degree of experimenting is required providing ambient noise does not block out the targeted audio.

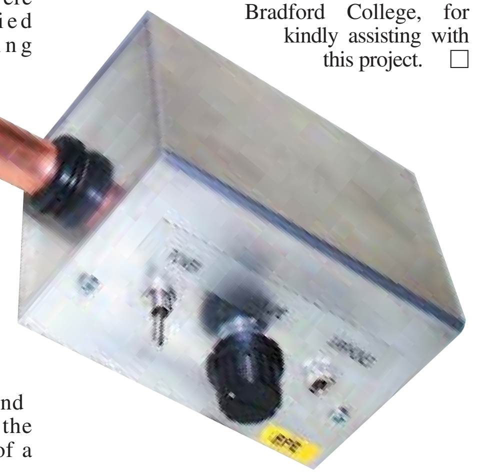
Point the reflector dish in the general direction of interest. As shown in Fig.6, hold the Super-Ear unit *in front* of the reflector. For optimum pick-up determine the focal length for the chosen "dish", i.e. the distance at which the microphone is held from the centre of the reflector.

A trial and error method sufficed for the prototype, with interesting results. Using this method, low level sounds (only just audible but unintelligable) were amplified using an aluminium bowl of diameter 200mm as the parabolic element, and having a focal point of 90mm.

Of course, the larger the dish diameter (typically up to 800mm) and the more parabolic the shape, the stronger the illumination. The gain of a satellite dish antenna, for example, increases six decibels simply by doubling its size.

Because holding the parabolic element can muffle sound pick-up, it is worthwhile mounting it on a simple support via strong adhesive pads or glue such as Araldite.

Avoid using fixtures which involve drilling holes, except for the 10mm centre hole mentioned earlier. For bigger and heavier parabolic elements, the suggested method of home assembly as shown in Fig.6 can be used rather effectively.



Ideally Super-Ear should be suspended within a framework of struts to align with the centre and focal point of the dish for optimum audio pick-up

Drill a hole at the centre of the element equivalent to the diameter of the microphone, in this case 10mm. In terms of picking up sound this helps redirect the sound "illumination" relative to the size of microphone.

Acknowledgements

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