Fuzz/sustain unit for guitarists

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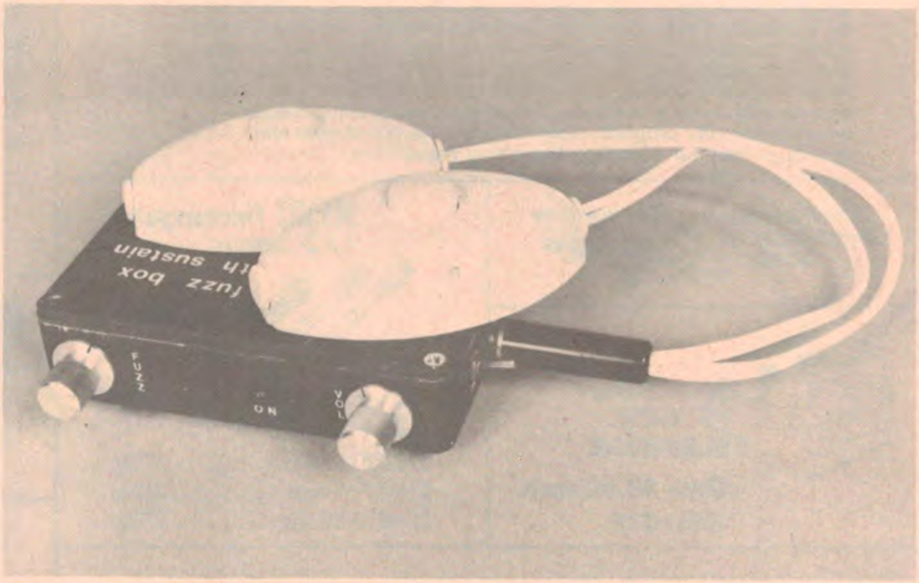
For that raunchy sound beloved of electric guitarists the world over, this simple little project is just the thing.

THE INVENTOR of the fuzz-tone is lost in history (rugged country, that), along with the discoverer of the wheel, the first chef, and the architect of square corners. However, his legacy is with us still, to the joy of those who like their music *loud,* and the despair of those who can't stand it that way!

Like the first bar-b-que, the first fuzz-tone was probably an accident — a blown speaker, perhaps, or a badly overdriven amplifier. However, the essential nature of the phenomenon did not long remain hidden, and keen guitarists soon had the fuzz by the short and curlies.

Fuzz-tone is to guitar what salt is to meat — it adds flavour and body. The ETI Fuzz Unit, based on the 'clever fuzz-box' circuit which appeared in the January '79 ETI, has an added bonus in an inbuilt sustain circuit, adding a bit of extra spice to the idea.

The device offers three distinctive sounds, in addition to the 'straight through' option: sustain, fuzz with sustain or fuzz without sustain.



How we did it

To explain how these sounds are realised, we have to consider the circuit diagram.

The input amplifier, IC1, is required to give the system some overall gain, to boost the treble response, and to present the correct load impedance to the instrument. The mid-range gain is set to 5, allowing 1 V peak-to-peak input signals before distortion, and producing the largest possible dynamic range. The frequency response is flat from 20 Hz to about 2 kHz, after which an 8 dB step provides a gentle treble boost up to 20 kHz, where the response is flat from 20 Hz to about 2 kHz, after which an 8 dB step provides a gentle treble boost up to 20 kHz, where the response is rolled-off.

Following the input stage is IC2/1, one half of an NE 571 compander IC configured as a conventional compressor with a fixed compression ratio of 2:1. This compression effectively halves the dynamic range of the incoming signal by attenuating high level signals and boosting low level ones; thus the signal hangs on — "sustains" — for much longer than it otherwise would. The compression also provides a constant ▶

HOW IT WORKS — ETI 562

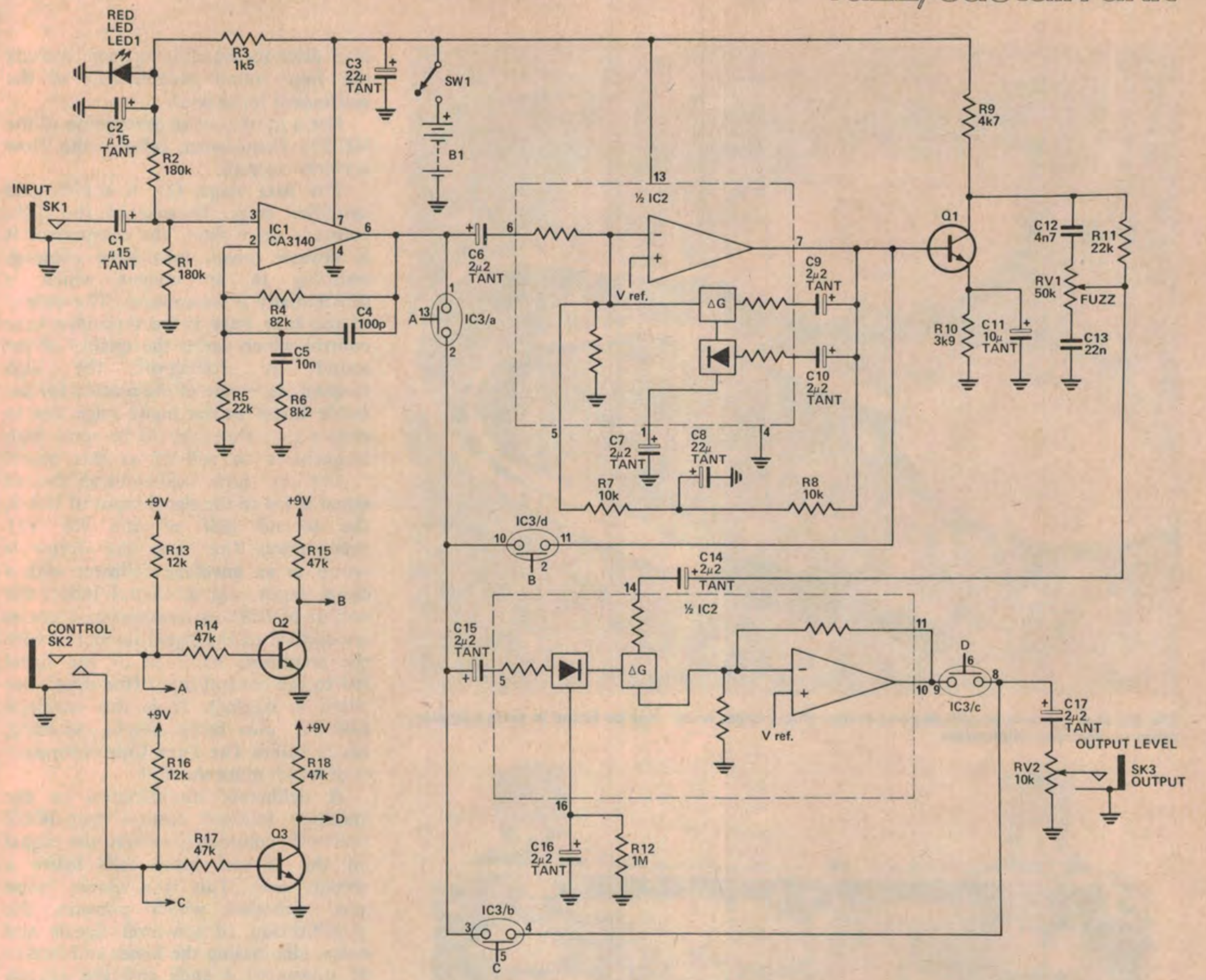
The input amplifier is a CA 3140, chosen for its low noise. The input impedance of the device is quite high, so the effective value is determined by the parallel combination of R1, R2; the values used give an impedance of 90k. R1 and R2 can be as low as 10k or as high as 1M, as long as they are the same and within this range.

The bias for the CA 3140 is filtered and regulated by R3, C2 and LED1; the LED also acts as a 'power on' indicator! The LED must be RED as other colours have a different forward voltage. The stage gain of 5 is set by the ratio of R4 and R5, while C4, C5 and R6 tailor the frequency response as described in the text.

IC2 is a dual gain control IC, NE 571, which may be set-up to implement a number of signal processing functions. Each half of the IC consists of a full wave rectifier acting on the control input, a variable gain cell (signal input), an operational amplifier and a bias system. The blocks may be set-up as, for example, a compressor, an expander, a limiter or an envelope follower. The compression/expansion ratio is internally set at 2:1 while the attack and release times are determined by an external timing capacitor and an internal resistor, the attack-to-decay time ratio is internally set at 1:5.

It is possible to vary both the compression ratio and the attack/decay ratio by the use of complex external circuitry, however the internally set values are adequate for the purpose of this gadget.

IC2/1 is configured as a compressor. The control signal is rectified and fed to an internal summing node. The rectified current is averaged by the external capacitor C7, and the average rectified current controls the gain of the variable gain cell ΔG. The gain cell is connected as an expandor in the feedback loop of the op-amp; a 3dB increase in the gain of the ΔG cell, producing a 6dB increase in feedback current to the summing node at



the op-amp input. If the input rises 6dB, the output can rise only 3dB.

The speed with which the gain changes to follow the input signal is determined by the rectifier filter capacitor C7. A small value will follow rapidly but will not fully filter low frequency signals on the control input. Any ripple on the gain control signal will modulate the signal passing through the ΔG cell, producing third harmonic distortion, so there is a trade-off between fast attack/decay times and distortion. C7 should not be reduced below about 0µ47.

The ΔG cell has a built-in compensation scheme for temperature variations and for cancelling odd harmonic distortion. A THD trim terminal is provided, but not used here, for cancelling even harmonic distortion caused by internal offset voltages. The operational amplifier is also internally compensated.

The non-inverting input is tied to an internal reference voltage and the summing node at the inverting input is tied internally to the ΔG cell output as well, the invert input is brought out of the package directly and via an internal resistor. This allows the gain of the stage to be controlled by internal components only or, as we have done, by an external network (R7, R8, C2). The output stage is capable of ± 20 mA output current.

For maximum dynamic range, the control (rectifier) input current should be as large as possible but should not exceed 300 µA (3 V using only the internal resistor). Maximum ΔG cell input current is 140 µA (2.8 V with internal components only).

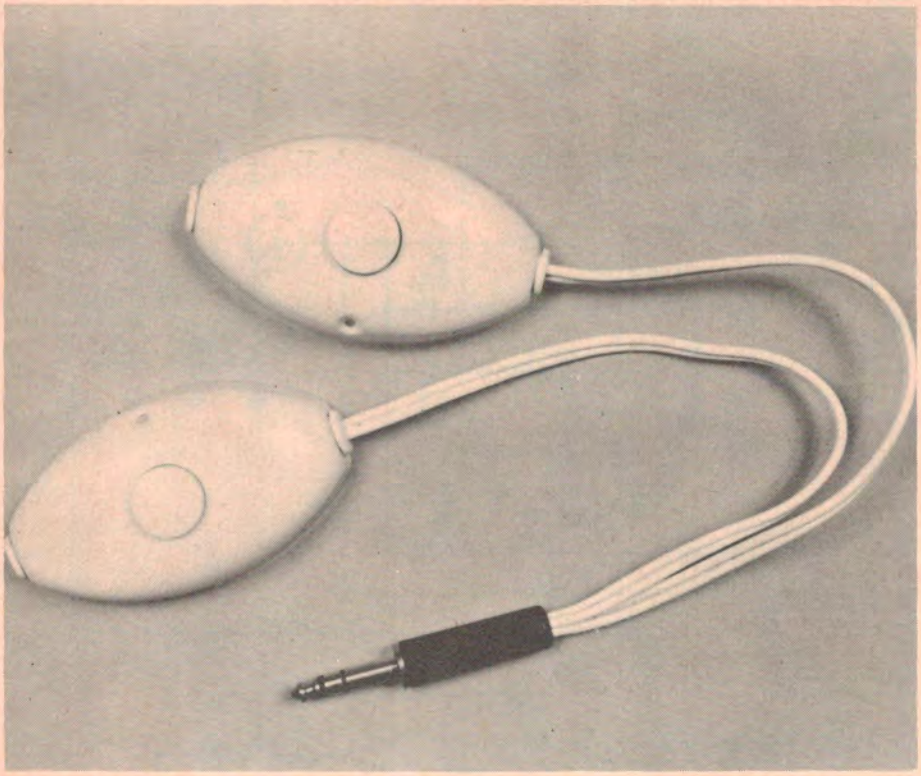
Q1 is a high gain amplifier which is always driven into hard clipping, as described in the text. R11, RV1, C12 and C13 form a tone control network which varies the fuzz-tone by rolling-off the top end. The clipping amplifier feeds the second half of IC2 which is connected as an envelope follower.

In the usual expander configuration the control and signal inputs are tied together, so that a 3 dB rise or fall at the input produces a 3 dB variation in the gain of ΔG, giving a 6 dB rise or fall at the output.

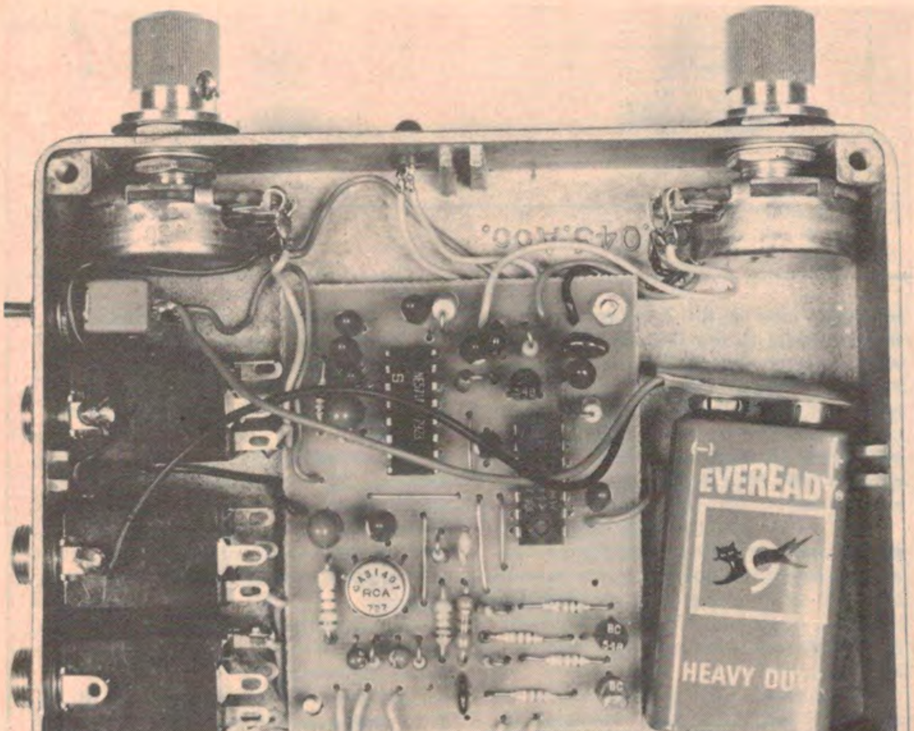
When connected as an envelope follower the control input is the signal whose amplitude envelope is being impressed on the straight-through signal, and a 3 dB variation of the control input will produce a 6 dB rise or fall at the output.

The attack/decay times of the follower are set by C16; it is best not reduced below about 0µ1.

The switching system uses a CA 4016 quad analog switch with Q2 and Q3 as drivers. With both control lines floating SWs A and C are closed, B and D open. When the fuzz control line is grounded Q3 cuts-off, opening C and closing D; similarly when the sustain line is grounded, A opens and B closes.



The switches we used are single-pole, double-throw types which may be found in some hardware stores or electrical wholesalers.



We housed the fuzz unit in a diecast aluminium box, type 043B. It's not as much of a squeeze as it looks. A piece of sponge rubber will secure the battery.

level drive to the clipping stage, making the fuzz sound independent of the instrument input level.

For a more precise description of the NE 571 Compander, refer to the 'How it works' section.

The fuzz stage, Q1, is a high gain amplifier stage. Because of the high, constant drive from the compressor it is always driven into hard clipping, resulting in an output which is substantially a squarewave. The output of the fuzz stage is fed through a tone control which varies the quality of the sound by rolling-off the high frequencies – one of the reasons for the treble boost at the input stage was to ensure that there would be some high frequencies to roll-off at this point!

The by now well-and-truly-fuzzed signal is fed to the signal input of IC2/2, the second half of the NE 571 Compander. This time the device is set-up as an envelope follower with a signal input and a control input; the output of IC2/2 is whatever frequencies are applied to the signal input but with the amplitude envelope of the signal fed to the control input (for details see 'How it works'). It is this envelope follower, plus some simple switching, which makes The Fuzz Unit so versatile – of which more shortly!

A deliberate modification to the envelope follower ensures that IC2/2 shuts-off completely when the signal on the control input falls below a certain level. This is a simple 'noise gate' function which prevents the amplification of low-level signals and noise, eliminating the hisses and buzzes of unwanted sounds and the squeals and howls of unexpected feedback! This function operates only when Fuzz function is selected.

As we mentioned earlier, The Fuzz Unit is capable of producing either sustain, fuzz with sustain, or fuzz without sustain. These variations are achieved by selecting the appropriate output and the appropriate drive to the control input of the envelope follower.

The switching system is entirely electronic, so the guitar signal never leaves the box even if the footswitches themselves are a dozen yards away. The signal is not required to travel long lengths of cable, and so is not attenuated or subject to interference. Also, single-pole non-audio type switches may be used, allowing a larger choice of switch types (audio quality footswitches are hard to find at the moment!).

Two switch lines are used to control

four electronic switches operating as two sets of change-over switches. One line controls SW A and SW B, (sustain on/off), the other controls SW C and SW D (fuzz on/off).

If neither fuzz nor sustain is selected, SW A and SW C are closed while SW B and SW C are open; the output of the unit is derived from the input pre-amplifier (so it will be a little louder and a little brighter than the guitar itself) via A and C.

If sustain is selected SWs A and B change over and the output is from IC2/1.

Selecting fuzz closes SW D and opens SW C. Whether it is fuzz with sustain or fuzz without sustain now depends on the position of the sustain select switch. If sustain is selected the drive to the control input of the envelope follower is the compressed signal from IC2/1; compression followed by expansion restores the amplitude envelope of the signal, so the output will have the dynamic characteristics of the original guitar sound, but will sustain for longer than usual. If sustain is not selected, the envelope follower control input is from the pre-amp, therefore the output of IC2/2 is the original signal expanded. Because of the value chosen for C7 and C16, the Fuzz Unit will produce a rather long 'delayed attack' effect when in this mode. If a shorter attack is wanted, C7 and C16 should be reduced; this will give a faster attack in 'fuzz without sustain', and enhanced attack in 'fuzz with sustain'.

Construction

The major problem in constructing this project is the non-availability of certain components. We were unable to find a reliable supply of audio-quality foot-switches, and for this reason opted for external switching using a pair of Clipsal No. 360 Series 250 V/10 A foot-switches. These are definitely not your usual stage gear, but they are very rugged and work very well indeed. Also, they are cheap!

For a touch more class use a commercial dual footswitch such as the Companion or the Roland FS 2 (around $15). With a bit of juggling you may be able to mount the project in one of these boxes. We used an 043B diecast aluminium box which is about the smallest possible container. If you are lucky enough to find a pair of audio footswitches and wish to mount them in the top you will need a deeper box than the 043B.

The usual method of switching the battery in effects boxes is to use a 6.5 mm socket with a separate pair of switching contacts — power is applied whenever a guitar is plugged in. We were unable to locate any of these sockets, so we have used an on/off switch.

Once the box has been drilled, the pc board should be assembled according to the circuit and layout diagram. Be sure that polarised components are correctly installed. The ICs should be put in last, as they are electrically fragile.

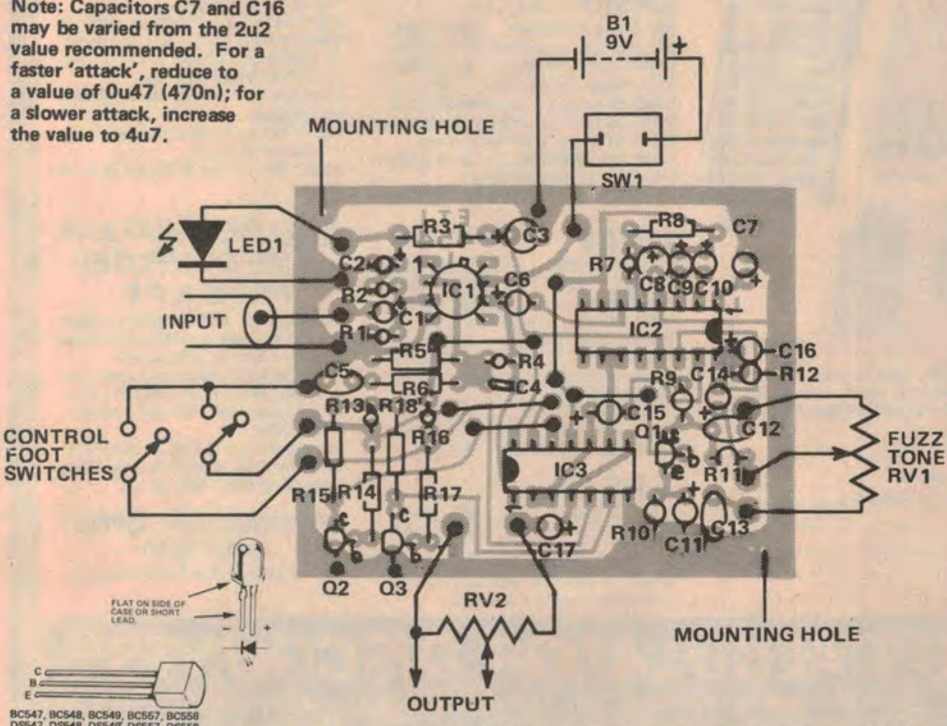
All solder joints should be clean and neat, with no stray connections across tracks on the pc board. Finally, interconnect the various major components as shown in the wiring diagram, using the shortest possible lengths of wire; use care when soldering the LED, as they are very heat sensitive and easily cooked.

Use insulated wire, and make sure that nothing is shorting to the box; the battery is best restrained by using a piece of double-sided tape.

After carefully checking that all connections are as they should be, apply power and you've got 'The Fuzz'.

Best results are obtained with the guitar output as high as it will go without causing distortion on loud notes when The Fuzz is switched to sustain only. ●

Note: Capacitors C7 and C16 may be varied from the 2u2 value recommended. For a faster 'attack', reduce to a value of 0u47 (470n); for a slower attack, increase the value to 4u7.



The pc board patterns are on page 113.

PARTS LIST - ETI 454

Resistors	all ½W, 5%
R1, R2	180k
R3	1k5
R4	82k
R5	22k
R6	8k2
R7, R8	10k
R9	4k7
R10	3k9
R11	22k
R12	1M
R13	12k
R14, R15	47k
R16	12k
R17, R18	47k
RV1	50k lin.pot
RV2	10k log. pot
Capacitors	
C1, C2	15u tantalum
C3	22u tantalum
C4	100p disc ceramic
C5	10n greencap
C6, C7	2u2 tantalum
C8	22u tantalum
C9, C10	2u2 tantalum
C11	10u tantalum
C12	4n7 greencap
C13	22n greencap
C14—C17	2u2 tantalum
Semiconductors	
Q1—Q3	BC548
LED1	TIL 22OR or similar
IC1	CA 3140
IC2	NE 571
IC3	CD4016

Miscellaneous
Metal box, 043B or similar; pc board - ETI 454; 9V battery, type 216; DPST miniature switch; two phone-jack sockets, mono; 1 phone jack socket, stereo; two knobs; pc board spacers; nuts and bolts.