PAPER TERMITE

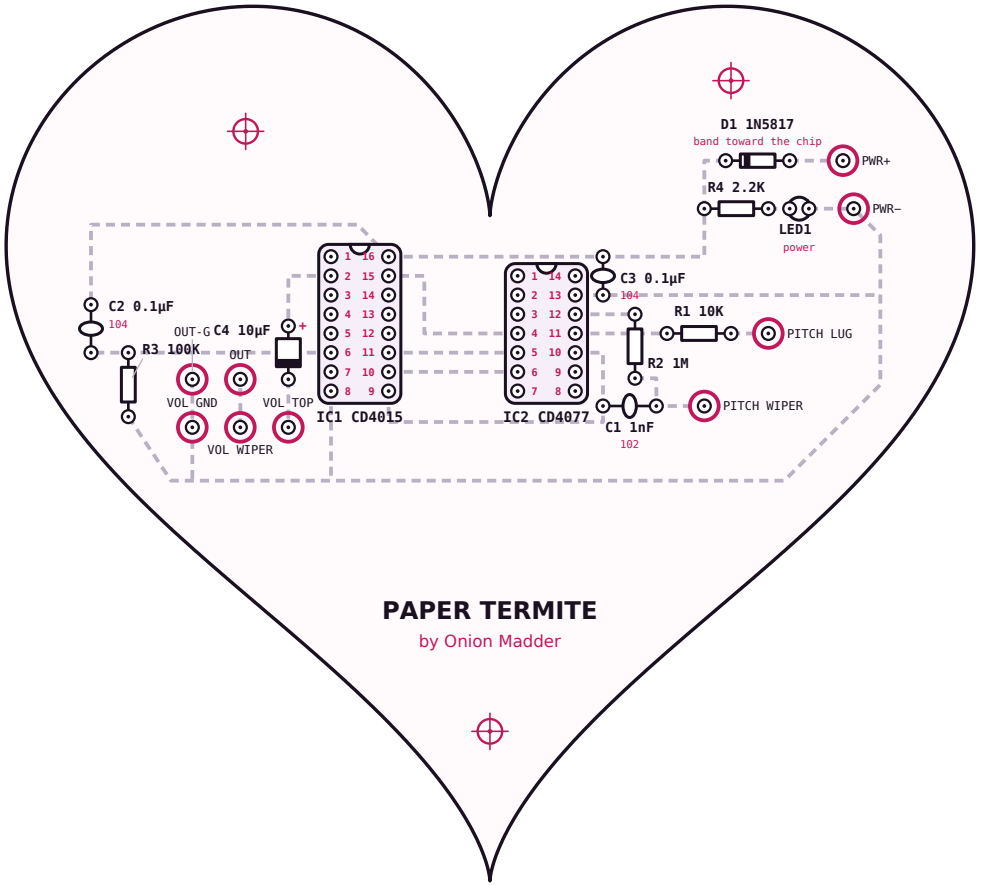
a shift-register noise box as a paper circuit · two hearts, print at 100% / Actual size

Onion Madder // messopedals.com · paper-circuit method after Peter Blasser / Ciat-Lonbarde

this bar must measure 100 mm

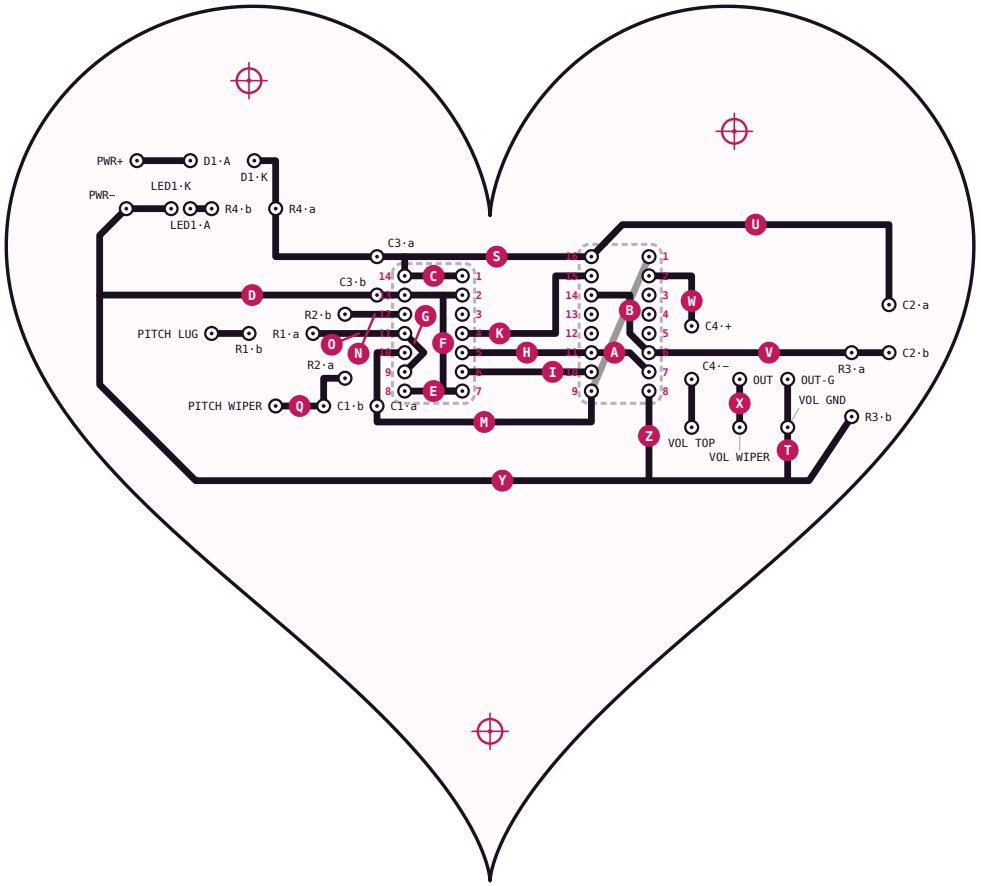
FRONT - parts side

parts go in from this face · the pitch and volume pots, the jack and power on wires



BACK - solder side

glued behind the front · mirror image · bare wire along every line



Cut each heart out on its own outline. Never fold this sheet and cut both at once: the two sides come out misaligned.

Build-up: a blank sheet folded in half and glued shut is the core. Glue the FRONT heart on one face, cut the core to its edge, then glue the BACK heart on the other face with its outline matching that edge. Lay it on a cardboard box and poke every hole from the front with pointed tweezers. Four layers: front, two core layers, back. The target marks are an extra check for the very careful.

Paper Termite

a two-chip shift-register noise box, from a ticking rhythm to a metallic hiss, as a full heart-shaped paper circuit

This one is a **noise box**. A shift register passes a row of bits along one place on every clock tick, and an XNOR gate feeds two of them back in at the start. The pattern that comes out looks random, but it repeats every 127 ticks, and that is the point of it.

Turn the pitch knob down and the 127-step pattern comes slowly enough to hear as a chattering rhythm. Turn it up and the pattern repeats hundreds of times a second, so it becomes a buzzy, metallic hiss with a pitch of its own. Two chips do all of it: a CD4015 for the register and a CD4077 for the gate and the clock.

What a paper circuit is

A paper circuit is a circuit board made of paper. The sheet you print is the board: the FRONT shows where every part sits, and the BACK is the same drawing mirrored, with the wiring on it. The printed front and back are glued to the two faces of a plain sheet folded in half, so the board is four sheets of paper thick, and every hole is poked through all four layers. The parts go in from the front, chips included, soldered straight to the paper. On the back, part legs bend along the printed lines, and bare wire covers the lines a leg cannot reach. Where one line has to cross another, an insulated wire hops over it. The power switch and the jacks hang off the board on wires. Nothing is etched and nothing is cut but paper: a printer, a glue stick, scissors, pointed tweezers, a cardboard box and a soldering iron are the whole kit.

The method is Peter Blasser’s, from Ciat-Lonbarde. His paper circuits are a great idea, but they are complicated, full of unusual parts and hard to troubleshoot. This series takes circuits people already know, built from common parts, and makes a paper circuit something a beginner can try.

63 steps. Page 1 is the board itself; everything after it is the recipe.

Reading the sheet

Front: each part is drawn where it sits, with its value printed next to it. The faint dashed lines are only a preview of what connects on the back. The ringed holes are for wires going off the board: PWR+ and PWR− for power; PITCH LUG and PITCH WIPER for the pitch pot; VOL TOP, VOL WIPER and VOL GND for the volume pot; OUT and OUT-G for the output jack. The three target marks are an extra check for the very careful: on the finished heart they sit on top of each other.

Back: every bold black line is bare wire or a bent part leg. The lines with a letter in a circle are bare wire, and the steps name them by that letter; the short unlettered ones are a part’s own leg, bent along the line. The one lighter, thicker line across IC1 is J1, the only insulated wire on the board. Small pink numbers beside the chip holes are the pin numbers. Some lettered wires run between a chip’s two rows of legs: that is on purpose, and the steps say which pins each one touches.

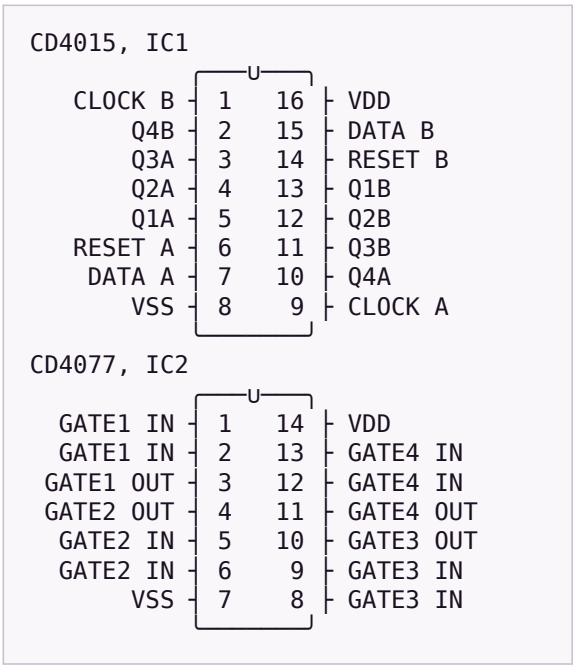
A shift register with XOR feedback is the classic way to make noise from logic chips, and the two-gate RC clock is out of every CMOS cookbook. The paper-circuit method is Peter Blasser’s / Ciat-Lonbarde’s. This layout and the words are Onion Madder’s.

What you'll need

- **1× CD4015 dual 4-stage shift register (IC1)** · *spot it:* CD4015 printed on top, notch or dot at pin 1, 16 pins. It solders straight to the paper, no socket.
- **1× CD4077 quad XNOR (IC2)** · *spot it:* CD4077 printed on top, 14 pins. It has to be the XNOR: a CD4070 has the same pins but its gates do the opposite, and nothing here would run.
- **1× 1M resistor (R2)** · *spot it:* brown-black-green
- **1× 100K resistor (R3)** · *spot it:* brown-black-yellow
- **1× 10K resistor (R1)** · *spot it:* brown-black-orange. It stays in series with the pitch pot, so the knob can't short the clock at the bottom of its travel.
- **1× 1 nF ceramic (C1)** · *spot it:* printed 102. It sets the clock's range: don't mix it up with the 104s.
- **2× 0.1 µF ceramic (C2, C3)** · *spot it:* printed 104. C2 makes the start-up pulse; C3 sits across the supply at IC2.
- **1× 10 µF electrolytic (C4)** · *spot it:* a little can, stripe marks the − leg. The output's DC blocker.
- **1× 1N5817 Schottky diode (D1)** · *spot it:* small black body, gray or silver band marks the cathode
- **1× LED (LED1) and a 2.2K resistor (R4)** · *spot it:* the power light. The LED's long leg is +, the flat side of the rim −; 2.2K is red-red-red
- **1× B500K pot (pitch)** · *spot it:* marked B500K; B = linear. Only two of its lugs are used. It hangs off the board on wires, so any style fits.
- **1× A100K pot (volume)** · *spot it:* marked A100K; A = log, the right taper for volume. On wires too.
- **1× SPST toggle** · *spot it:* for power; it hangs off the board on wires
- **1× jack** · *spot it:* the output, on wires
- **Bare tinned wire, and insulated wire** · *spot it:* bare for the traces on the back, insulated for J1 and for every wire off the board
- **Power: a 9V battery and snap, or a 2.1 mm DC jack and a 9V pedal supply** · *spot it:* the usual pedal supply is center-negative
- **A second sheet of plain printer paper, a glue stick, scissors, pointed tweezers and a cardboard box** · *spot it:* the blank sheet becomes the core; the tweezers poke the holes and the box takes the points

Before you start

The chip, from above



Both chips sit on the sheet exactly like this, notch toward the top edge, IC1 on the left and IC2 on the right. On IC1, pins 3, 4, 5, 12 and 13 stay empty on purpose: those are the stages the loop does not need. On IC2, gates 4 and 3 are the clock, gate 2 is the loop gate, and gate 1 is spare, with pin 1 on the supply, pin 2 on ground and pin 3 empty.

Paper burns. Keep the iron moving, quick joints, and don’t rest it on the sheet. Work over something that isn’t flammable, and keep a damp sponge handy.

Chips straight in. Both chips are soldered straight to the paper with no socket, and several bare wires run between their rows of legs on the back. Keep each joint quick: touch, flow, lift.

XNOR, not XOR. IC2 must be a CD4077. A CD4070 fits the same holes and does nothing useful here.

Mind the can. C4 is polarized: the stripe is the − leg, and the sheet marks the + hole.

Assembly

The sheet is the circuit board, four sheets of paper thick: the two printed hearts glued to the two faces of a plain sheet folded in half. Each heart is cut out on its own, and the back lines up with the front by its edge, so there is nothing to fold and nothing to misalign.

Print at 100% / "Actual size". Fit-to-page shrinks it and the holes stop matching the chips’ legs.

STEP	DO
1	Print page 1 on plain printer paper at 100% / Actual size.
2	Measure the 100 mm bar at the top right of the sheet. If it isn’t 100 mm, fix the print scale and print again.
3	Cut out the FRONT heart along its outline. Then cut out the BACK heart along its own outline. Don’t fold the printed sheet and cut both at once: the two sides come out misaligned.
4	Fold a second, blank sheet of printer paper in half. Glue-stick the whole inside, close it, and press it flat. That’s the core: two sheets thick.
5	Glue-stick the back of the FRONT heart.
6	Press the FRONT heart onto one face of the core, smoothing it flat from the middle out.
7	Cut the core away around the FRONT heart, following its edge, so the core is the same heart shape.
8	Glue-stick the bare side of the core.
9	Lay the BACK heart on it, printed side out, with its outline matching the edge all the way around, and press it flat. Now it’s four sheets thick. The 3 target marks are there for the very careful: hold the heart up to a light and the targets on the two sides should sit on top of each other.
10	Let the glue set for a few minutes. Then lay the heart front side up on a cardboard box, and poke the 30 chip holes straight down through all four layers with pointed tweezers, held closed. The box takes the points.
11	Poke the other 29 dots and rings the same way. Check the back and open any hole that didn’t come all the way through.
12	Check the fit: push each chip into its holes until its legs come through on the back. If a leg won’t go, open that hole a little more.

Start in the middle: IC1 and the wires under it

Everything builds outward from the two chips. IC1 first, with the two bare wires between its rows and the one insulated wire.

> Quick dabs only. Paper scorches if you sit on it: touch, flow, lift.

STEP	DO
13	Push the CD4015 into the IC1 holes from the front, notch toward the top edge (the drawn notch). It is the 16-pin chip, on the left.
14	On the back, bend pins 1, 8, 9 and 16 outward slightly so the chip can’t fall out.
15	Trace A: bare wire from pin 11 straight across between the rows, then a short step down to pin 7. Solder at pin 11 and pin 7. It passes close to pin 6 without touching it.
16	Trace B: bare wire from pin 14 straight across between the rows, down beside the left row past pins 4 and 5, and out to pin 6. Solder at pin 14 and pin 6.
17	J1: an insulated wire from pin 9 to pin 1, across the back of the chip. It crosses traces A and B, which is why it is insulated. Strip just the ends and solder at both pins.
18	Check with a meter before going on: pin 6 must not beep to pin 7, and pins 3, 4, 5, 12 and 13 must not beep to anything.

IC2 and the wires under it

Three wires cross IC2 straight from one row to the other, a ground wire runs between the rows to join two of them, and one short wire hops around a pin.

STEP	DO
19	Push the CD4077 into the IC2 holes from the front, notch toward the top edge. It is the 14-pin chip, on the right.
20	On the back, bend pins 1, 7, 8 and 14 outward slightly.
21	Trace C: bare wire straight across from pin 1 to pin 14, then on up a little to where the +V line will run. Solder at pin 1 and pin 14.
22	Trace D: bare wire straight across from pin 2 to pin 13, then on out to the right, all the way to the right side of the ground line. Solder at pin 2 and pin 13; the rest gets soldered as its parts go in.
23	Trace E: bare wire straight across from pin 7 to pin 8. Solder at both.
24	Trace F: bare wire between the rows, just inside the left row, from trace D down to trace E, ending at pin 7. Solder where it meets D and at pin 7.
25	Trace G: bare wire from pin 11 a little way in between the rows, past pin 10 without touching it, and back out to pin 9. Solder at pin 11 and pin 9.
26	Check with a meter: pin 10 must not beep to pin 9 or pin 11, and pin 3 must not beep to anything.

Between the chips

Four wires join the chips: two straight across the gap, the loop wire with a jog, and the clock, which goes the long way, down the right of IC2 and back under it.

STEP	DO
27	Trace H: bare wire straight across the gap from IC1 pin 11 to IC2 pin 5. Solder at both.
28	Trace I: bare wire straight across the gap from IC1 pin 10 to IC2 pin 6. Solder at both.
29	Trace K, the loop wire: bare wire from IC2 pin 4 left into the gap, up, and across to IC1 pin 15. Solder at both.
30	Trace M, the clock: bare wire from IC2 pin 10 out to the right, down past pins 9 and 8, back left under both gaps, and up into IC1 pin 9. Solder at IC2 pin 10 and IC1 pin 9; C1 joins it later.

The clock, right of IC2

Gates 4 and 3 of IC2 make the clock. R1 and the pitch pot set its speed with C1, and R2 closes the loop.

> C1 is the 102. A 104 there would slow the clock a hundred times.

STEP	DO
31	R2, 1M (brown-black-green): legs into R2·a and R2·b.
32	Trace N: bare wire from IC2 pin 12 out to the right, to R2·b. Solder at pin 12 and R2·b.
33	R1, 10K (brown-black-orange): legs into R1·a and R1·b. Bend R1·b's leg to the PITCH LUG pad and solder at both.
34	Trace O: bare wire from IC2 pin 11 out to the right, under R2·b without touching it, to R1·a. Solder at pin 11 and R1·a.
35	C1, 1 nF (102): legs into C1·a and C1·b. Solder C1·a on trace M.
36	Trace Q: bare wire from R2·a across and down to C1·b, then on to the PITCH WIPER pad. Solder at R2·a, C1·b and PITCH WIPER.

Power corner and the +V line

Power comes in on two pads at the top right. D1 only lets current through one way, so power hooked up backwards does nothing; C3 steadies the supply at IC2 and the LED says it's on.

> D1's band goes in D1·K, toward the chips.

STEP	DO
37	D1, 1N5817: band end into D1·K, plain end into D1·A. Bend D1·A's leg to the PWR+ pad and solder at both.
38	Trace S, the +V line: bare wire from IC1 pin 16 straight along over the top of IC2, then up to D1·K. Solder at pin 16, where trace C meets it, and at D1·K.
39	C3, 0.1 µF (104): legs into C3·a and C3·b. Solder C3·a on trace S and C3·b on trace D.

40	R4, 2.2K (red-red-red): legs into R4·a and R4·b. Solder R4·a on trace S.
41	LED1: long leg into LED1·A, short leg into LED1·K. Bend R4·b's leg to LED1·A and solder at both. Bend LED1·K's leg to the PWR− pad and solder at both.

The left side: the start-up pulse and the output

C2 and R3 give both registers a short reset when the power comes on, so the pattern always starts from a state that runs. C4 takes the sound from IC1 pin 2 to the volume pot.

> C4's stripe goes toward the bottom of the heart.

STEP	DO
42	Trace U: bare wire from IC1 pin 16 up over the top of IC1, out to the left, and down to C2·a. Solder at pin 16.
43	C2, 0.1 µF (104): legs into C2·a and C2·b. Solder C2·a where trace U ends.
44	R3, 100K (brown-black-yellow): legs into R3·a and R3·b.
45	Trace V: bare wire from IC1 pin 6 straight out to the left to C2·b. Solder at pin 6, R3·a and C2·b.
46	C4, 10 µF: long + leg into C4·+, striped leg into C4·−. It stands across trace V: the wire runs between its legs on the back.
47	Trace W: bare wire from IC1 pin 2 out to the left and down to C4·+. Solder at pin 2 and C4·+.
48	Bend C4·−'s leg to the VOL TOP pad and solder at both.

The ground line

One ground wire runs from R3 down to the bottom, along it, and up the right side to PWR−, and everything that goes to ground drops onto it.

STEP	DO
49	Trace Y, ground: bare wire from R3·b down to the bottom, along the bottom under both chips, up the right side to PWR−. Solder at R3·b, at PWR−, and where trace D meets it.
50	Trace Z: bare wire from IC1 pin 8 straight down to the ground line. Solder at pin 8 and where it meets Y.
51	Trace T: bare wire from the OUT-G pad straight down through the VOL GND pad to the ground line. Solder at OUT-G, VOL GND and where it meets Y.
52	Trace X: bare wire from the VOL WIPER pad to the OUT pad. Solder at both.
53	Snip every leg tail that sticks past its joint.

Off the board

The pitch pot, the volume pot, the jack, the toggle and the power hang off the pads on insulated wire.

> If the volume knob feels backwards, swap its two outer wires.

STEP	DO
54	Pitch pot: the middle lug (the wiper) to PITCH WIPER, and one outer lug to PITCH LUG. The other outer lug stays empty. If the knob runs backwards, move the PITCH LUG wire to the other outer lug.
55	Volume pot: one outer lug to VOL TOP, the middle lug to VOL WIPER, the other outer lug to VOL GND. No pot? A short wire from VOL TOP to VOL WIPER and it plays at full volume.
56	Output jack tip to OUT, sleeve to OUT-G.
57	A wire from one lug of the power toggle to the PWR+ pad.
58	Battery: the snap’s red (+) wire to the toggle’s other lug, its black (−) wire to PWR−. Or a DC jack for a center-negative 9V pedal supply: the jack’s sleeve (+) lug to the toggle’s other lug, its center-pin (−) lug to PWR−.

Check, then play

Meter it before you play it. These readings come from the design rather than readings off my board.

STEP	DO
59	Turn the volume all the way down. Clip the battery on or plug the supply in, and toggle on. LED1 should light.
60	Meter IC1 pin 16 to IC1 pin 8: the supply voltage minus about 0.3 V. IC2 pin 14 to IC2 pin 7: the same.
61	Meter IC1 pin 6 to ground: zero, once the power has been on for a moment.
62	Meter IC2 pin 10 to ground: a meter reads a running clock as about half the supply. Zero or the full supply means the clock is stopped.
63	Bring the volume up slowly and sweep the pitch knob: from a ticking, chattering pattern at one end to a buzzy hiss at the other.

Voltage check

METER BETWEEN	EXPECT (toggle on)
PWR+ pad → PWR− pad	supply voltage
IC1 pin 16 → IC1 pin 8	supply voltage minus about 0.3 V
IC2 pin 14 → IC2 pin 7	the same
IC1 pin 6 → ground	zero
IC2 pin 10 → ground	about half of pin 14: the clock running
IC1 pin 2 → ground	somewhere near half, and wandering

If it won’t sing

SYMPTOM	CHECK
Dead, LED dark	D1 in backwards (the band goes in D1·K), the power wires reversed, or the toggle not between the supply’s + and PWR+.
LED lit, silent, IC2 pin 10 at zero or the full supply	The clock is stopped. Check C1 is the 102, R2 on trace N, trace Q to PITCH WIPER, trace G around pin 10, and both pitch pot wires. IC2 must be a CD4077.
LED lit, clock running, silent	The output side: trace W to C4·+, C4’s stripe toward the bottom, and the volume pot: outer lugs on VOL TOP and VOL GND, wiper on VOL WIPER (or the wire from VOL TOP to VOL WIPER).
A plain tone or a steady click that never changes pattern	The register is stuck. Power off, wait a few seconds, power on. If it sticks again, meter IC1 pin 6: it should be zero, so look at R3 and trace V. Then traces H, I and K, and trace A from IC1 pin 11 to pin 7.
The knob does nothing over half its turn	The pitch pot is on the wrong two lugs. Use the wiper and one outer lug.
Paper scorched or a hole tore	Glue a scrap of paper over the back, re-poke, carry on. It is paper.

Things to try

- **A photocell for the pitch pot.** An LDR across PITCH LUG and PITCH WIPER, the way I ran the Hive Drone, and the noise follows your hand. Untried.
- **Slower:** C1 at 10 nF (103) moves the whole range down by ten, so the bottom of the knob is a slow, clicky sequence. Untried.
- **Into the Paper Ring Mod.** The Termite on one input and an oscillator on the other. Untried.