Stompboxology™
Volume 13, Number 4

Envelope Effects

The loudness contour of music is called the amplitude envelope, or simply envelope. Envelope effects generate voltages that drive filters, VCAs, and other voltage controlled blocks.

This issue explores envelope and related effects, stressing the derivation of control feeds. The category holds tremendous potential, owing to the ease with which the builder may realize effects unknown in commercial hardware.

Definitions

The several control voltages differ in shape and in temporal relation to the axe feed. A *tracking envelope* is a voltage that varies smoothly and continuously with the input (Fig. 1–3).

A *triggered interval* is a fixed voltage that commences with onset of a note. An *indefinite interval* (Fig. 1–4) lasts as long as the note rings, while a *fixed interval* (Fig. 1–8) lasts a set time unrelated to the note's duration. From these two intervals may be derived *sequential intervals*, which fire automatically after the first interval; *delayed intervals*, which don't commence until some set time after the onset of the note; or *mixed intervals*, which are combinations of two or more interval types.

A *triggered envelope* (Fig. 1–10) uses an interval to make an envelope with selectable attack, decay, amplitude, and direction; and whose creation may involve an intermediate control voltage (Fig. 1–9). Though resembling the envelope of a plucked string, the triggered envelope does not vary from one note to the next. Analog music synthesizers use triggered envelopes to mimic stringed-instrument dynamics.

A *ramp* refers to a changing voltage of unipolar slope. The ramp may rise (positive slope) or fall (negative slope). Ramps derive from triggered intervals, and come in two basic shapes. A *linear ramp* (Fig. 1–6) results from charging a capacitor through a constant-current path. Slope remains fixed throughout the cycle. Charging a capacitor through a resistor generates an *exponential ramp* (Fig. 1–5), whose slope falls continuously from beginning of the cycle to the end. Feeding a ramp through a nonlinear transfer block alters contour or reverses direction (Fig. 1–7). The ramp ends with *reset*, a quick return to the starting voltage.

A persistent switching state generated in response to single notes or chords is called a *ratchet*. The switching state may change with each note, or with some set number of notes.

Beginner's View details the generation of these control voltages.

Voltage Controlled Blocks

VCBs occupy a long chapter in the *Cookbook*, which will not be repeated here. Two projects in this issue use VCBs not detailed previously. One is the NE570 configured as a voltage controlled mixer (VCM), which easily becomes a voltage controlled panner (VCP). The VCM is realized by feeding the current outputs of two 570 gain cells into one I–V converter, while driving the two control ports off equal but inverted voltages (Fig. 2–1). The VCP results from the same control scheme, while giving each gain cell its own I–V converter, and tying the two signal inputs to a common source (Fig. 2–2).

In this issue:

Second, a pair of 570s become a two-input voltage controlled crosspanner (VCCP; Fig. 2–3). The VCCP is realized by wiring a pair of VCMs such that the signal inputs follow parallel paths, while the control inputs wire crosswise. The result is for two inputs to swap outputs under control of dual-inverse voltages.

Beginner's View

Q. I've checked out Fig. 1. The connection between circuits and waveforms isn't obvious to a beginner. I'd like you to explain them in simple terms.

A. Certain functions are common to all envelope generators. The first is a scaling amp to achieve the desired sensitivity. This amp may entail nothing more than a feed off the existing preamp, or may require a more involved circuit, like the modified log amp of Fig. 1–4. The next stage is some type of rectifier, to make the voltage unipolar; and usually an integrator, to smooth it. The circuitry just described yields a tracking envelope, which varies in proportion to the loudness of the input signal. Fig. 1–3 gives another example of a tracking envelope generator, one whose output swings to ground in the absence of an input signal. Circuit branching from this point depends on what type of control voltage you want to derive.

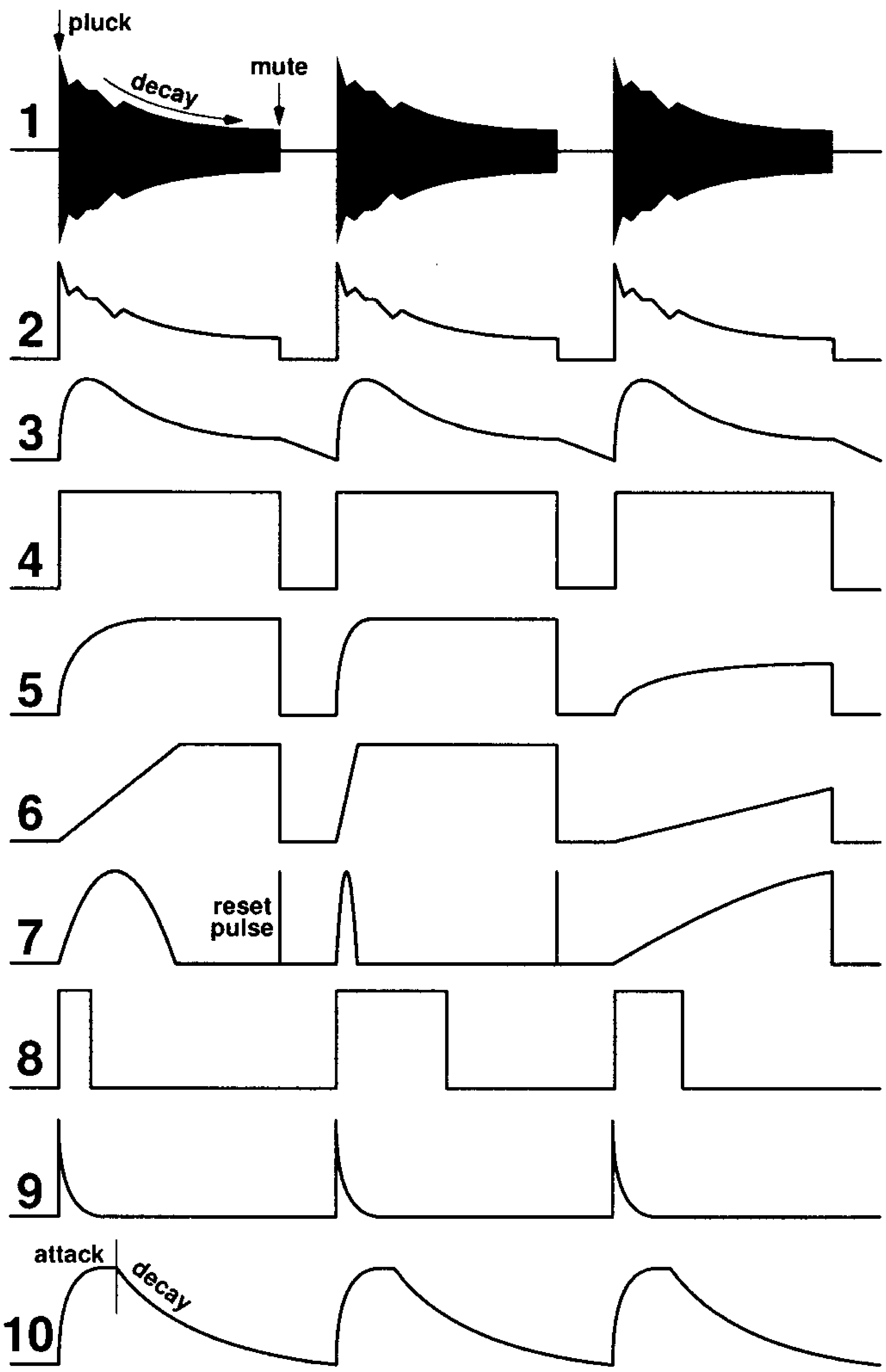
Q. How do I generate an indefinite interval?

A. An indefinite interval commences with plucking the string and holds pretty much as long as you let the note ring. Fig. 1–4 (schematic) shows one approach. A1 is the scaling amp, here a modified log amp to prevent clipping.

Q. What's the point of using a modified log amp?

A. We want an indefinite interval to hold as long as you hold the note, yet reset instantly when you mute the string. Long hold requires high gain from the scaling amp. A conventional amp would clip, charging C2 & C3 to such a high voltage that an audible delay might occur between the time you mute the strings and the time the interval resets. The modified log amp—D1-D2-R3—allows high gain while limiting maximum voltage swing to about 3V peak.

D3 & C2-3 rectify and integrate the voltage. D4 makes an auto-variable decay path that minimizes the delay between muting and reset. A3 is a comparator that generates the interval itself. When you strike and hold the



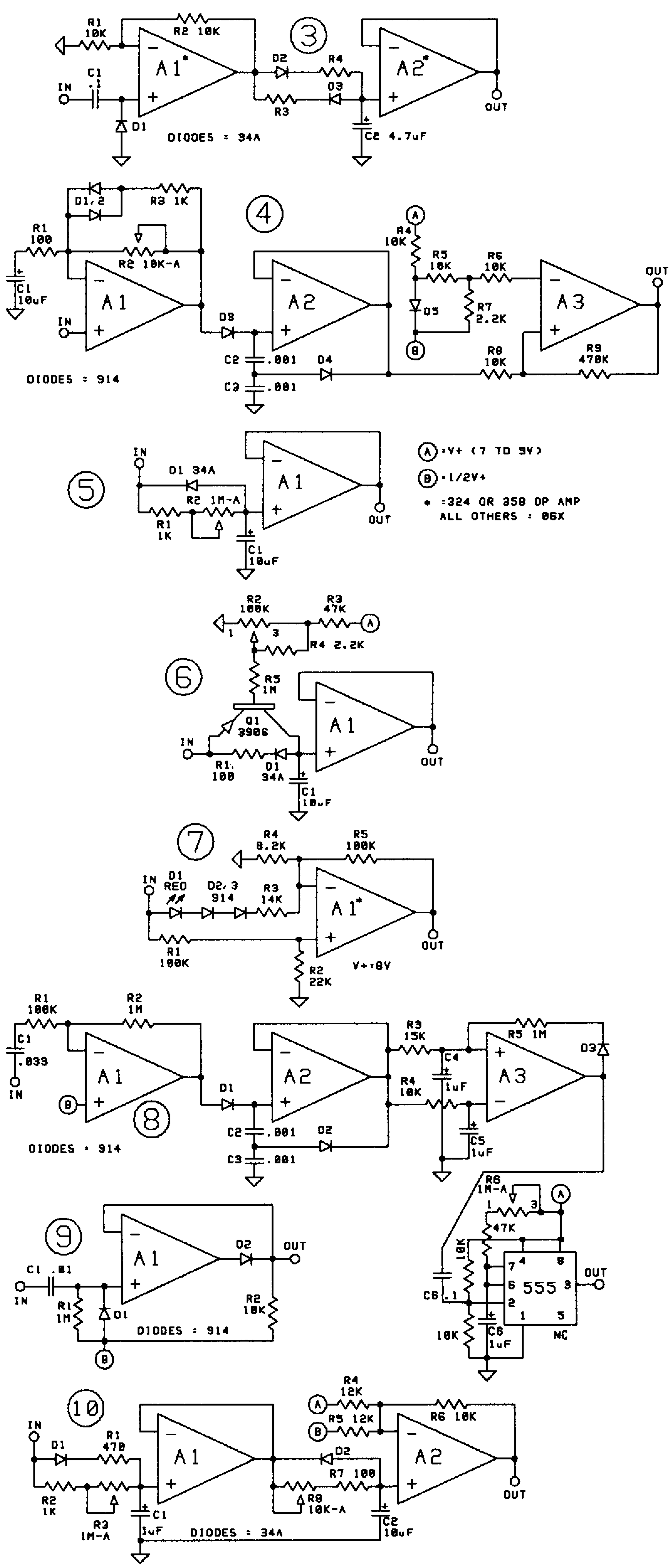


Fig. 1. Above: basic control voltages derived from the music envelope; above right: schematics whose numbers correspond to waveforms they generate. 1—Unrectified music envelope begins when string is plucked, followed by natural decay, then muting by the player. 2—Positive rectification yields an envelope too rough for most control applications. 3—Integration smooths the control envelope; choice of R3, R4, & C2 determines relative attack and decay times. 4—A triggered interval, realized by boosting axe feed in modified log amp A1, integrating in A2, whose output drives comparator A3; bias network R4/5/6/7-D5 avoids a shift in sensitivity over the supply range 5–15V. Circuit generates an indefinite interval that commences with onset of the note and lasts until the player mutes the string. 5—Exponential ramps, derived from #4. Charging of a cap through a resistor is characterized by a continuously falling slope. Discharge path D1 causes ramp to return to baseline with no audible delay when the interval ends. 6—Linear ramps, derived from #4 by applying comparator output to the input of variable constant-current source Q1; C1 charges linearly, discharges with no audible delay through D1-R1 when the interval ends. 7—Result of feeding #6 through one type of nonlinear transfer block; derives a secondary ramp that changes direction; many other shapes are possible. This and other direction-changing blocks generate a second positive pulse when the input signal falls from peak to zero. 8—These are also triggered intervals, but use of a 555 one-shot makes their duration independent of trigger-note duration; component values shown allow selection of interval from ~50 ms to 1.1 seconds. 9—Differentiating #4 or #8 in a circuit that senses only the positive voltage swing. These impulses are used to derive other control feeds. If desired, a negative impulse can be derived from the falling edge. 10—Feeding #9 through a variable attack/decay network generates control impulses that continue automatically, irrespective of whether the player holds the note. With proper attack and decay, these simulate the dynamics of a plucked string, allowing the impression of natural dynamics on constant tones. Asterisked (*) op amps must be types whose input range embraces the negative supply, such as 324, 358, etc.

note, the comparator's output flips to its positive limit. When you mute the note, the comparator's output flips to its negative limit.

Q. What's going on with R4-5-6-7-D5, tied to the inverting input of A3?

A. The voltage applied to the inverting input sets the comparator threshold. This circuit's ideal threshold turned out to be a fraction of a volt above 1/2V+. The voltage at the juncture of R4-D5 is one diode drop (0.6V) above 1/2V+. This gives too high a threshold, so we divide that voltage using R5-R7. The point of using this method is that, no matter how the supply voltage changes, the voltage at the comparator's inverting input remains the same fractional voltage above 1/2V+, so the comparator's functional threshold

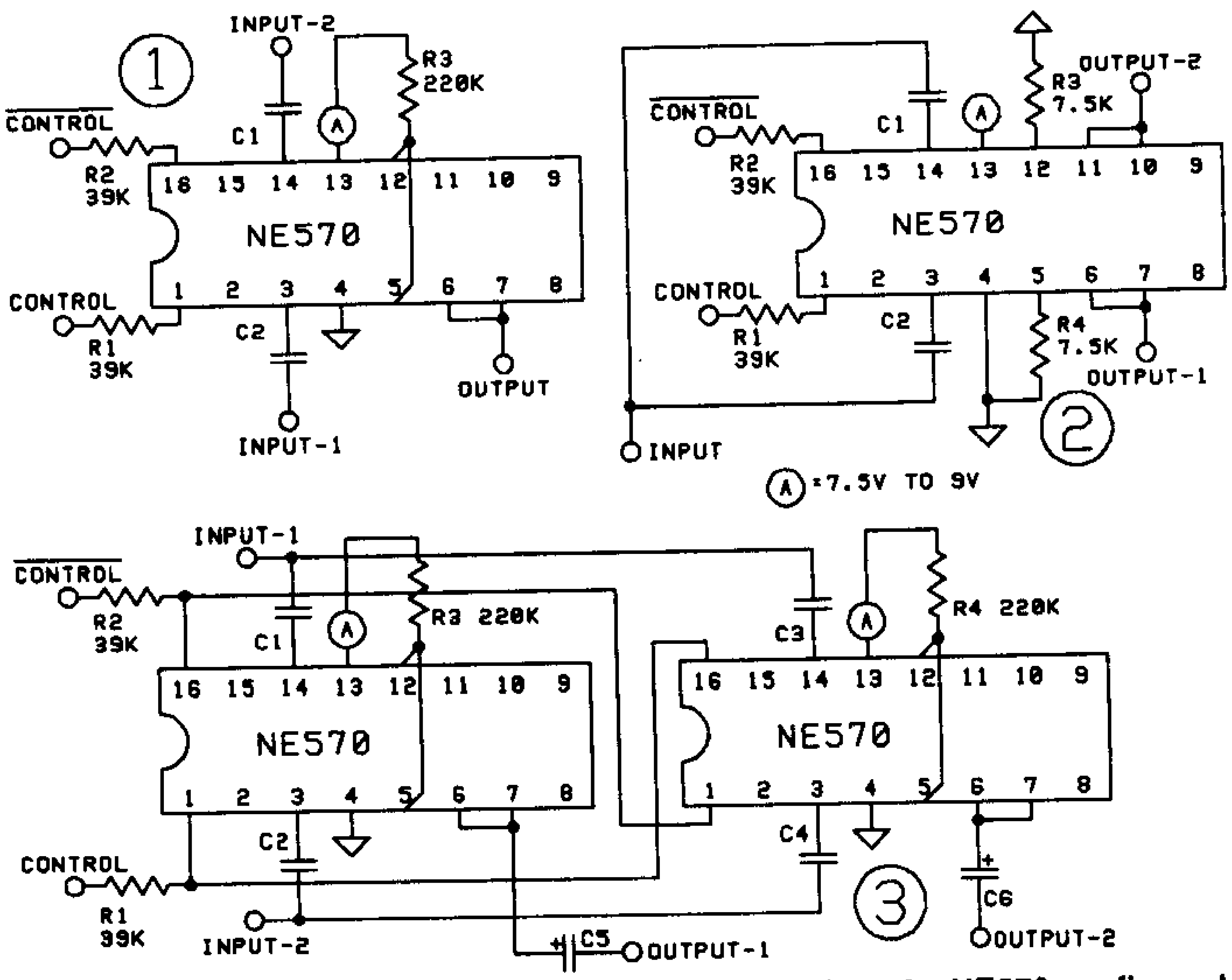


Fig. 2. 1—NE570 configured as voltage controlled mixer. 2—NE570 configured as voltage controlled panner. 3—Two VCMs configured as two-input voltage controlled cross-panner.

will not shift over the supply range 5–16V.

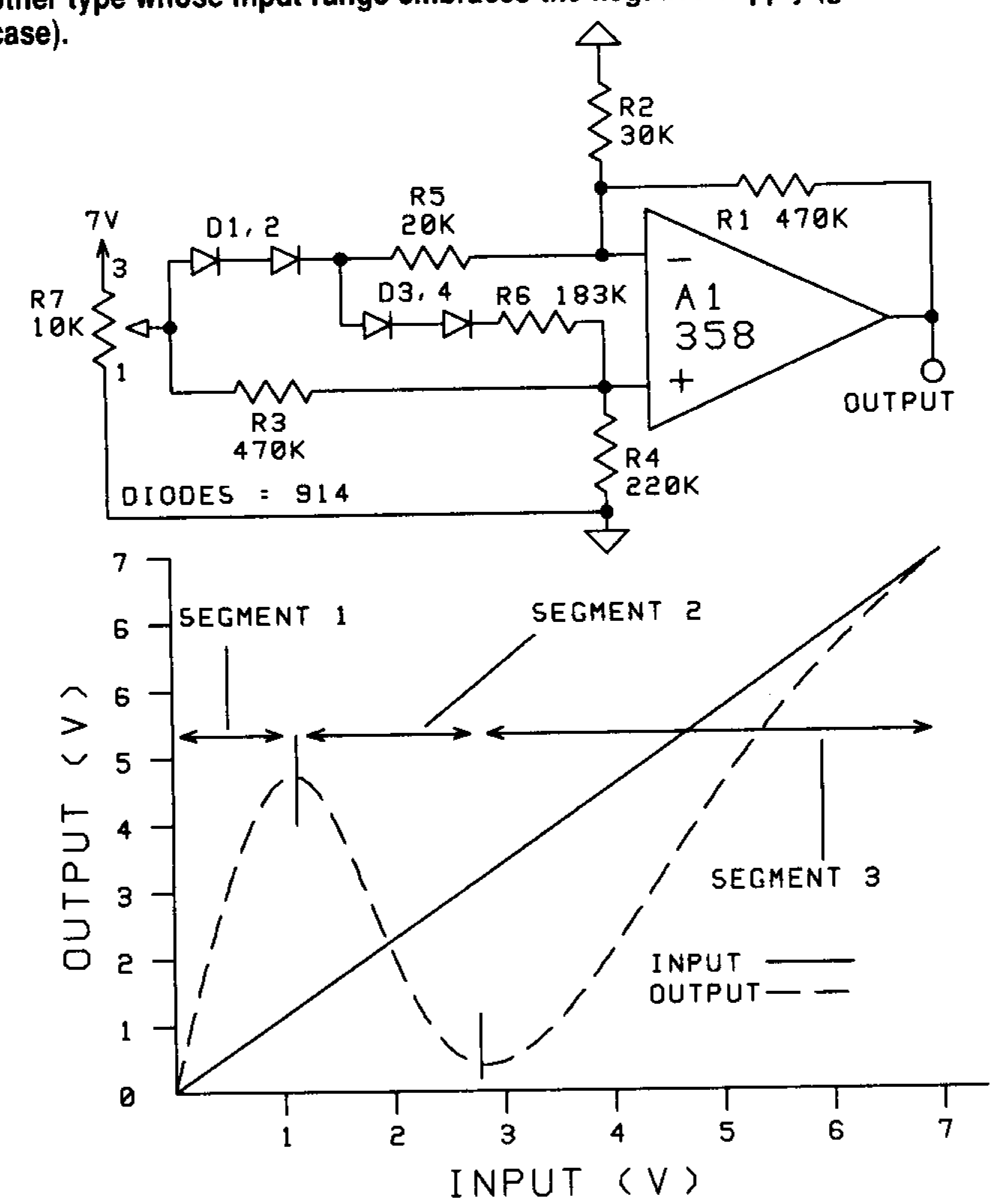
Q. What about generating an exponential ramp?

A. Couldn't be simpler. Feed the output of Fig. 1–4 into Fig. 1–5. A fixed voltage charging a capacitor through a resistor makes an exponential ramp. Pot R2 controls ramp time.

Q. And a linear ramp?

A. Feed the output of Fig. 1–4 into Fig. 1–6. Applying a fixed voltage to a constant current path makes a linear ramp. Q1 in Fig. 1–6 acts as a constant current path whose action varies under control of pot R2.

Fig. 3. Nonlinear transfer block that reverses slope polarity twice. Pot R7 varies input voltage from 0 to 7V. First output segment rises much faster than input voltage due to (a) op amp gain = [1 + (470K÷30K)] and (b) divider action of R3-R4. Once input exceeds the forward drop of D1-2, current flows through R5 into A1's inverting input, causing output voltage to fall at a rapid rate due to large gain of R1÷R5. Third segment begins when input voltage exceeds forward drop of D3-4; voltage applied through R6 overcomes negative tendency, then causes rise. Input again equals output at about 7V. Op amp must be 358, 324, or other type whose input range embraces the negative supply (ground in this case).



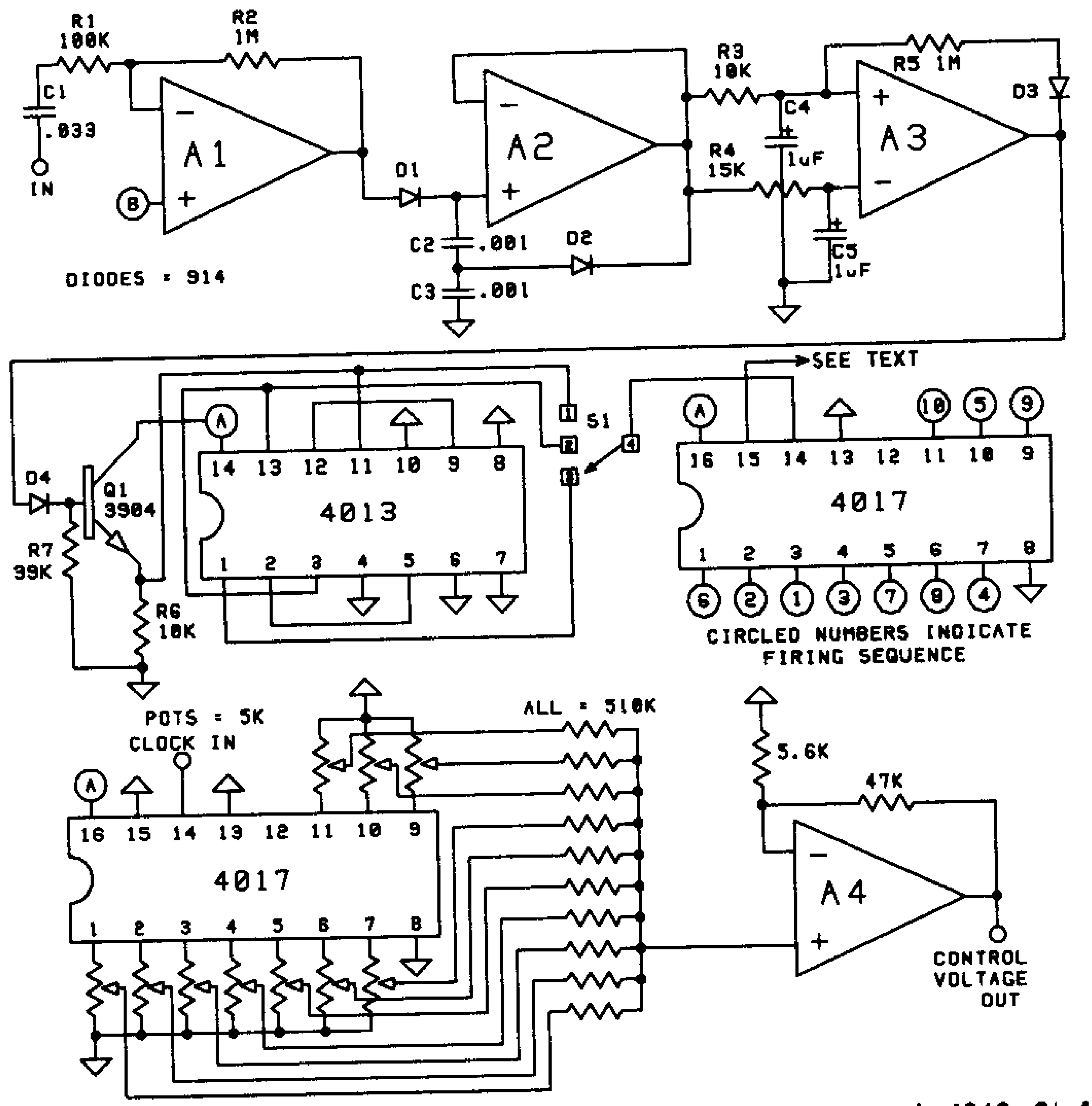


Fig. 4. Op amps form impulse trigger; D4-Q1 condition output to trip 4013 ÷2/÷4 circuit; S1 selects single, ÷2, and ÷4 feed for 4017 counter. When S1 selects position 1, 4017's output advances once per note; when S1 selects position 2, 4017 advanced every other note; when S1 selects position 3, 4017 advances every fourth note. To derive proper wiring configuration, first set the number of 4017 outputs desired; for example, 5. The 6th pin in the firing order—pin-1—ties to pin-15, the reset pin. In that configuration, 4017 pins 3-2-4-7-10 will go high in that sequence, then return to pin-3 and start over. Apply same principle to any number of pins between 2 and 9; to get all 10 pins to fire in sequence, ground pin-15. The 4017 shifts every other clock input cycle. The bottom 4017 circuit delivers 10 sequential control voltages, each one independently variable by setting of its 5K pot; A4 must be TS271 or similar type whose input range embraces ground in a single supply system. A wah sequencer results if the 4017 is driven off an oscillator and the control voltage drives a bandpass filter.

Q. I notice that both exponential and linear ramps decay when the indefinite interval does. How and why does this occur?

A. We call this return to resting voltage *reset*. To get the ramp to reset, we provide a discharge path for C1 that doesn't activate until the interval ends. The simplest way is a diode; D1 in Figs. 1–5 and 1–6. C1 in both cases discharges through D1 into the output stage of the comparator driving the ramp circuit.

Q. Why the series resistor (R1) in Fig. 1–6?

A. It isn't truly necessary, but shows one way to slow the reset pulse to prevent clicks in the signal path. Or you could place a cap in the comparator's negative feedback loop, as we did in Attack-O-Matic VIII (C3 on the AOM8 schematic). This slows the rise and fall of the comparator output.

Q. I notice that some circuits specify 1N34A germanium diodes, while others use 1N914 silicon diodes. What factors guide diode selection?

A. Forward drop and leakage. Germanium diodes begin to conduct when the voltage across them reaches ~0.3V. Silicon diodes take about 0.6V. We use germanium diodes when we want the voltage coming through the diode to track the input voltage as closely as possible.

Leakage refers to the current that flows through the diode in the reverse direction. For example, germanium diodes kill the function of the auto-variable decay network D3-D4-C2-C3 in Fig. 1–4, because the charge in two 0.001µF caps is so small that it quickly leaks through D3. Silicon diodes exhibit much lower leakage than germanium types; and, for special applications, you can get diodes with lower leakage than 1N914s'. Germanium diodes work fine in Figs. 1–5 and 1–6, because the charge in the 10µF cap

(continued on page 14)

Project No. G341
Envelo-Matic III

Dynamics of one instrument impressed on those of another instrument.

Circuit Function

The primary input—which modulates the intensity of the secondary input—couples through C26-R22 to IC2-a, an amp whose gain varies 1–11 under control of R26. IC2-a output feeds a compressor consisting of IC3-a and associated components. The compression control voltage couples through D2 to buffer IC4-a, thence to the expansion control port, pin-16 of IC5.

The signal to be modulated—the secondary input—couples through C2-R3 to voltage follower IC2-b, whose output couples through treble emphasis network C1-R2 to terminal-1 of S1. IC2-b's output also couples through C4 to an independently running compressor consisting of IC3-b and associated components. This compressor's output couples to terminal-3 of S1, whose pole (terminal-2) couples through C11 to expander IC5, which gets its control input off IC4-a.

The output is taken at pin-10 of IC5, coupling through C13-R14 to output level pot R27. The net signal path is noninverting.

The result of these arrangements is for the compression control voltage generated by the primary input to drive the expansion of the secondary signal, which is compressed (or not) depending on the setting of S1. The net secondary signal path is noninverting.

IC4-b and associated components form a servo that keeps the outputs of all three 570 segments near 1/2V+ despite changes in supply voltage.

Use

Pots & switch have these functions:

R26	primary input gain
R27	output level
S1	secondary feed select compressed/non-compressed

Initial settings: R26 centered, R27 fully CCW, S1 either position. Connect a guitar to the primary input; connect a line-level signal source to the secondary input. Connect the output to the desired monitoring device. While strumming a chord on the guitar connected to the primary input, slowly turn R27 CW and note that the intensity of the guitar signal controls the loudness of the secondary feed. Toggle S1 and note the changes in sound.

Notes

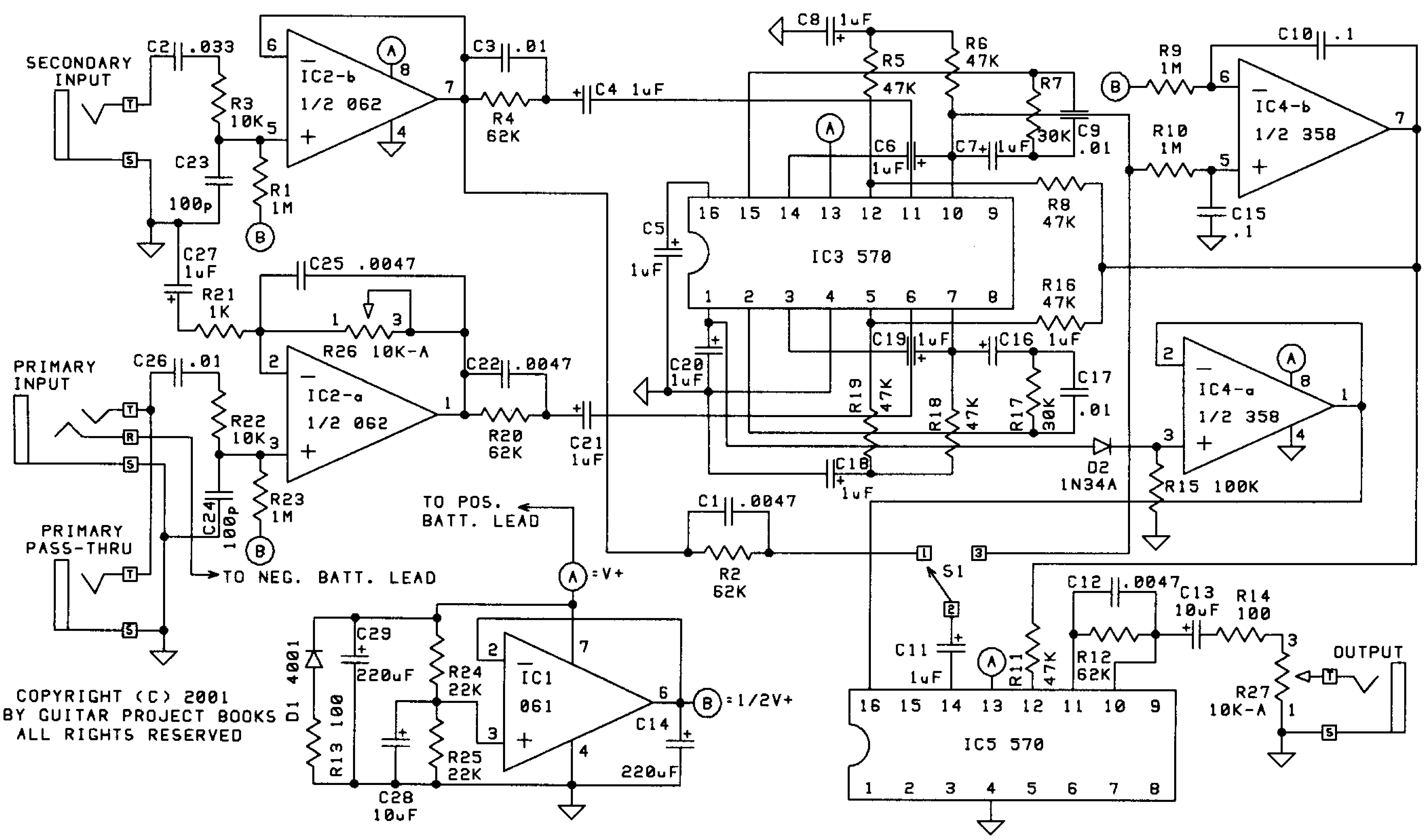
ENV3 differs from others by (optionally) compressing the modulated feed. Treble emphasis/de-emphasis, which is part of the companding system, is also added to the uncompressed version of the secondary feed.

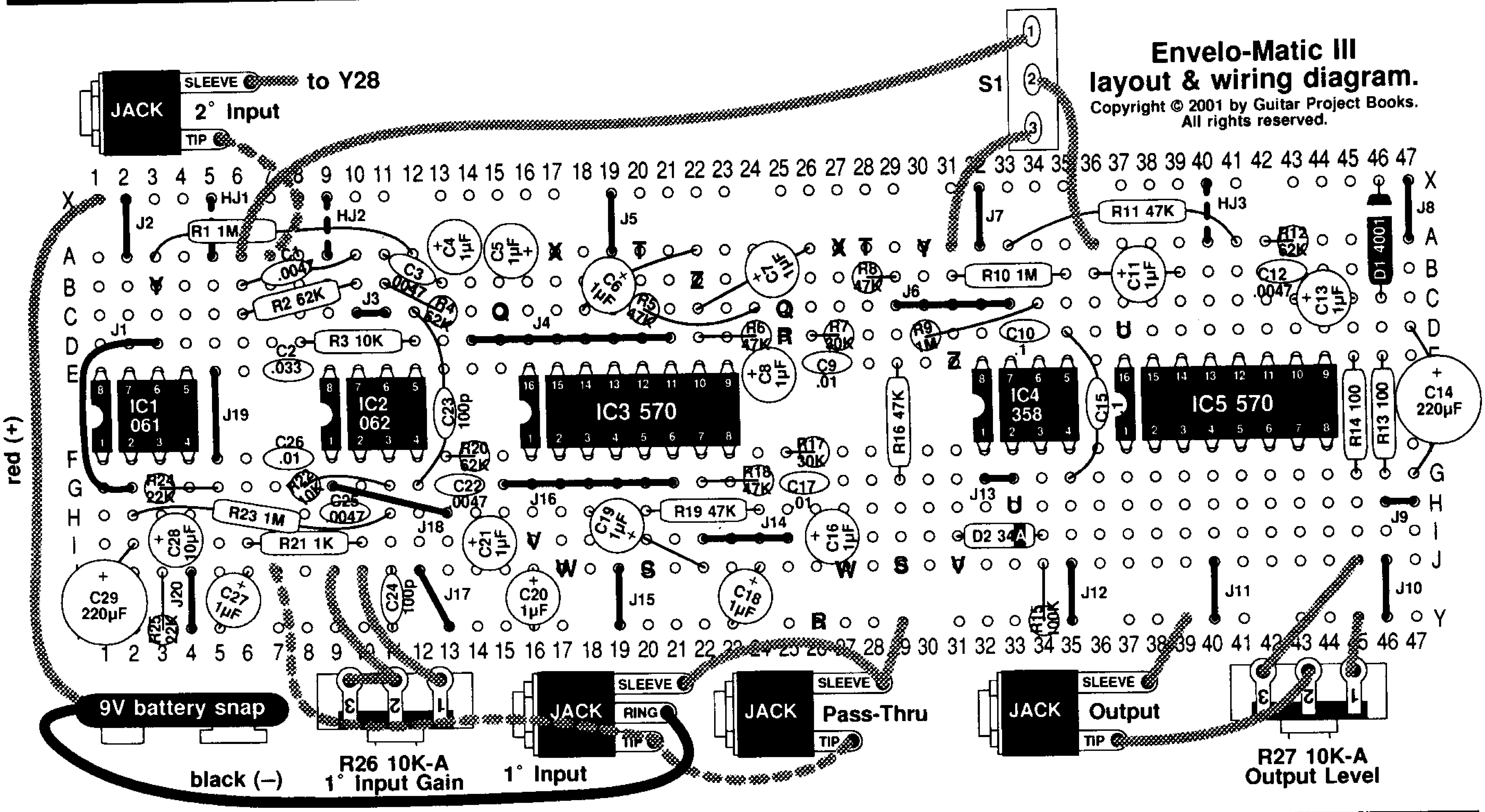
Although the control feed drops very low when the primary feed is silent, the unit is not self-gating and thus is not suited to modulating constant tones of high amplitude.

The 1μF values of C5 & C20 are nominal. They let the unit respond smartly, yet without excessive ripple. The builder may alter these values to taste. Increase value to slow the response and reduce ripple even further; reduce value to accelerate response.

The prototype drew 9 milliamps.

Envelo-Matic III schematic.





Parts List/Soldering Checklist

Circuit Board Radio Shack p/n 276-170; Hosfelt p/n 42-183; or DC Electronics p/n J4-404

IC Sockets

[x] 8-pin for IC1; pin-1 to F1
[x] 8-pin for IC2; pin-1 to F9
[ ] 16-pin for IC3; pin-1 to F16
[x] 8-pin for IC4; pin-1 to F32
[ ] 16-pin for IC5; pin-1 to F37

Resistors

[x] **install hidden jumpers HJ1 (X5-A5) & HJ2 (X9-A9) before soldering R1]**

[x]	R1	1M	(brn-blk-grn)	A3-A12
[ ]	R2	62K	(blu-red-org)	C6-B10
[x]	R3	10K	(brn-blk-org)	D8-D12
[ ]	R4	62K	(blu-red-org)	B11-C13
[x]	R5	47K	(yel-vio-org)	C20-C24
[x]	R6	47K	(yel-vio-org)	D22-D24
[ ]	R7	30K	(org-blk-org)	D26-D27
[x]	R8	47K	(yel-vio-org)	B28-B29
[x]	R9	1M	(brn-blk-grn)	D30-C34
[x]	R10	1M	(brn-blk-grn)	B31-B35

[x] **install hidden jumper HJ3 (X40-A40) before soldering R11]**

[x]	R11	47K	(yel-vio-org)	A33-A41
[ ]	R12	62K	(blu-red-org)	A42-A43
[ ]	R13	100	(brn-blk-brn)	E46-G46
[ ]	R14	100	(brn-blk-brn)	E45-G45
[ ]	R15	100K	(brn-blk-yel)	J34-Y34
[x]	R16	47K	(yel-vio-org)	E29-G29
[ ]	R17	30K	(org-blk-org)	F25-F26
[x]	R18	47K	(yel-vio-org)	G22-G24
[x]	R19	47K	(yel-vio-org)	H20-H24
[ ]	R20	62K	(blu-red-org)	F13-F14
[ ]	R21	1K	(brn-blk-red)	I6-I10
[x]	R22	10K	(brn-blk-org)	G8-G11
[ ]	R23	1M	(brn-blk-grn)	H2-H11
[ ]	R24	22K	(red-red-org)	G3-G5
[ ]	R25	22K	(red-red-org)	J3-Y3

Bare Wire Jumpers

[x]	J1	D3-G2
[x]	J2	X2-A2
[x]	J3	C10-C11
[x]	J4	D14-D21
[x]	J5	X19-A19
[x]	J6	C29-C33
[x]	J7	X32-A32
[x]	J8	X47-A47
[x]	J9	H46-H47
[x]	J10	J46-Y46
[x]	J11	J40-Y40
[x]	J12	J35-Y35
[x]	J13	G32-G33
[x]	J14	I22-I25
[x]	J15	J19-Y19
[x]	J16	G15-G21
[x]	J17	J12-Y13
[x]	J18	G9-H13
[x]	J19	E5-F5
[x]	J20	J4-Y4

Capacitors

[ ]	C1	0.0047	B6-A10
[ ]	C2	0.033	E7-E8
[ ]	C3	0.0047	A11-B13
[ ]	C4	1µF	A13-A14 (+ lead to A13)
[ ]	C5	1µF	A15-A16 (+ lead to A16)
[ ]	C6	1µF	C18-A22 (+ lead to A22)
[ ]	C7	1µF	C22-A26 (+ lead to C22)
[ ]	C8	1µF	E24-E25 (+ lead to E24)
[ ]	C9	0.01	E26-E27
[ ]	C10	0.1	D33-D34
[ ]	C11	1µF	B36-B39 (+ lead to B36)
[ ]	C12	0.0047	B42-B43
[ ]	C13	1µF	C43-C45 (+ lead to C43)
[ ]	C14	220µF	D47-G47 (+ lead to D47)
[ ]	C15	0.1	D35-G35
[ ]	C16	1µF	I26-I27 (+ lead to I26)
[ ]	C17	0.01	G25-G26
[ ]	C18	1µF	J24-Y23 (+ lead to J24)
[ ]	C19	1µF	H18-J22 (+ lead to J22)
[ ]	C20	1µF	J16-Y16 (+ lead to J16)
[ ]	C21	1µF	I14-I15 (+ lead to I14)
[ ]	C22	0.0047	G13-G14
[ ]	C23	100pF	C12-G12
[ ]	C24	100pF	J11-Y11
[ ]	C25	0.0047	H9-H10
[ ]	C26	0.01	F7-F8
[ ]	C27	1µF	J6-Y5 (+ lead to J6)
[ ]	C28	10µF	I3-I4 (+ lead to I3)
[x]	C29	220µF	I2-Y1 (+ lead to I2)

Flying Jumpers (insulated wire)

[ ]	QQ	C15-C25
[ ]	RR	D25-Y26
[ ]	SS	J20-J29
[ ]	TT	A20-A28
[ ]	UU	D37-H33
[ ]	VV	I16-J31
[ ]	WW	J17-J27
[ ]	XX	A17-A27
[ ]	YY	B3-A30
[ ]	ZZ	B22-E31

Semiconductors

[ ]	D1	1N4001	X46-C46 (banded end to X46)
[ ]	D2	1N34A	I31-I34 (banded end to I34)
[ ]	IC1	TL061 op amp; pin-1 to F1	
[ ]	IC2	TL062 dual op amp; pin-1 to F9	
[ ]	IC3	NE570; pin-1 to F16	
[ ]	IC4	LM358 dual op amp; pin-1 to F32	
[ ]	IC5	NE570; pin-1 to F37	

Potentiometers (T=terminal)

[ ] R26 10K audio-taper T1 to J10, T2 to T3 and to J9
[ ] R27 10K audio-taper T1 to Y45, T2 to tip of output jack, T3 to J45

Jacks (T=terminal)

[ ] primary input jack (1/4" 3-terminal/stereo): tip to tip of pass-thru jack and to J7, ring to negative (–) battery lead, sleeve to Y29
[ ] pass-thru jack (1/4" 2-terminal/mono): tip to tip of primary input jack, sleeve to Y29
[ ] secondary input jack (1/4" 2-terminal/mono): tip to A7, sleeve to Y28
[ ] output jack (1/4" 2-terminal/mono): tip to terminal-2 of R27, sleeve to Y39

Switches (T=terminal)

[ ] S1 (SPDT slide or toggle switch): T1 to A6, T2 to A36, T3 to A31

9V Battery Leads

[ ] black (–) lead to ring of primary input jack
[ ] red (+) lead to X1

Project No. G342
Attack-O-Matic IV

Envelope triggered mixer, with variable ramp time and four possible gain patterns for each input.

Circuit Function

Signal Path: The primary input couples through C12 to voltage follower IC4-c, whose output couples to inverting amp IC4-d, which adds about 26 dB of treble emphasis above 700 Hz; thence through C10 to one input of voltage controlled mixer IC5. The secondary input couples through C5 to a path that is functionally identical to that of the primary input, but feeds the other half of IC5. A pass-thru jack is provided off the primary input.

The output is taken off pin-10 of C5, coupling through C8 to treble de-emphasis network R16-R17-C9. The net signal paths are noninverting.

Control Path: The output of IC4-c couples to modified log amp IC1-c, whose gain varies 1–101 by R36. IC1-c's output feeds halfwave rectifier IC1-d (with auto-variable decay network C15-C16-D8), whose output couples through R33 to comparator IC1-a. The comparator's output is normally low. When the audio level exceeds threshold, the comparator's output flips high. This voltage couples through attack-time pot R37 to R31-C14. The charging of C14 is an exponential ramp that forms the primary control voltage. An inverted version of this voltage is obtained from IC2-b; a positive reversing version is obtained from the output of IC3-a, and a negative reversing version is obtained from the output of IC3-b. Each of the four separate control feeds couples to one throw of two SP4T rotary switches, S1 and S2. The pole of S1 ties to one gain port of IC5 through R18; the pole of S2 ties to the other gain port of IC5 through R14. When the control voltage is at its negative limit, the gain of each half of the voltage controlled mixer approximates 0. When the control voltage is at its positive limit, the gain approximates 1.

The system functions thus: When audio at the primary input exceeds the comparator threshold, the circuit generates four separate control voltages. Any one of these voltages may be selected to affect two different inputs to a voltage controlled mixer.

Use

Pots and switches have these functions:

- **R36** trigger sensitivity
- **R37** ramp time, ~50 ms to 2 seconds
- **S1** primary control feed select
- **S2** secondary control feed select

Initial settings: S1, S2 fully CW (i.e, turned to throw #2). R36 & R37 centered. Connect an axe to the primary input, connect output to amp; at this point connect nothing to the secondary input or the pass-thru jack. Establish desired listening level. In this state an audible delay accompanies the emergence of each note. Adjust trigger sensitivity if necessary. Take S1 through its four positions and note the different dynamic profiles available.

Next, connect the pass-thru output to a blatant effect, such as a distortion box. Feed this effect's output to the secondary input. Take the controls through their ranges and note the sounds obtainable.

Notes

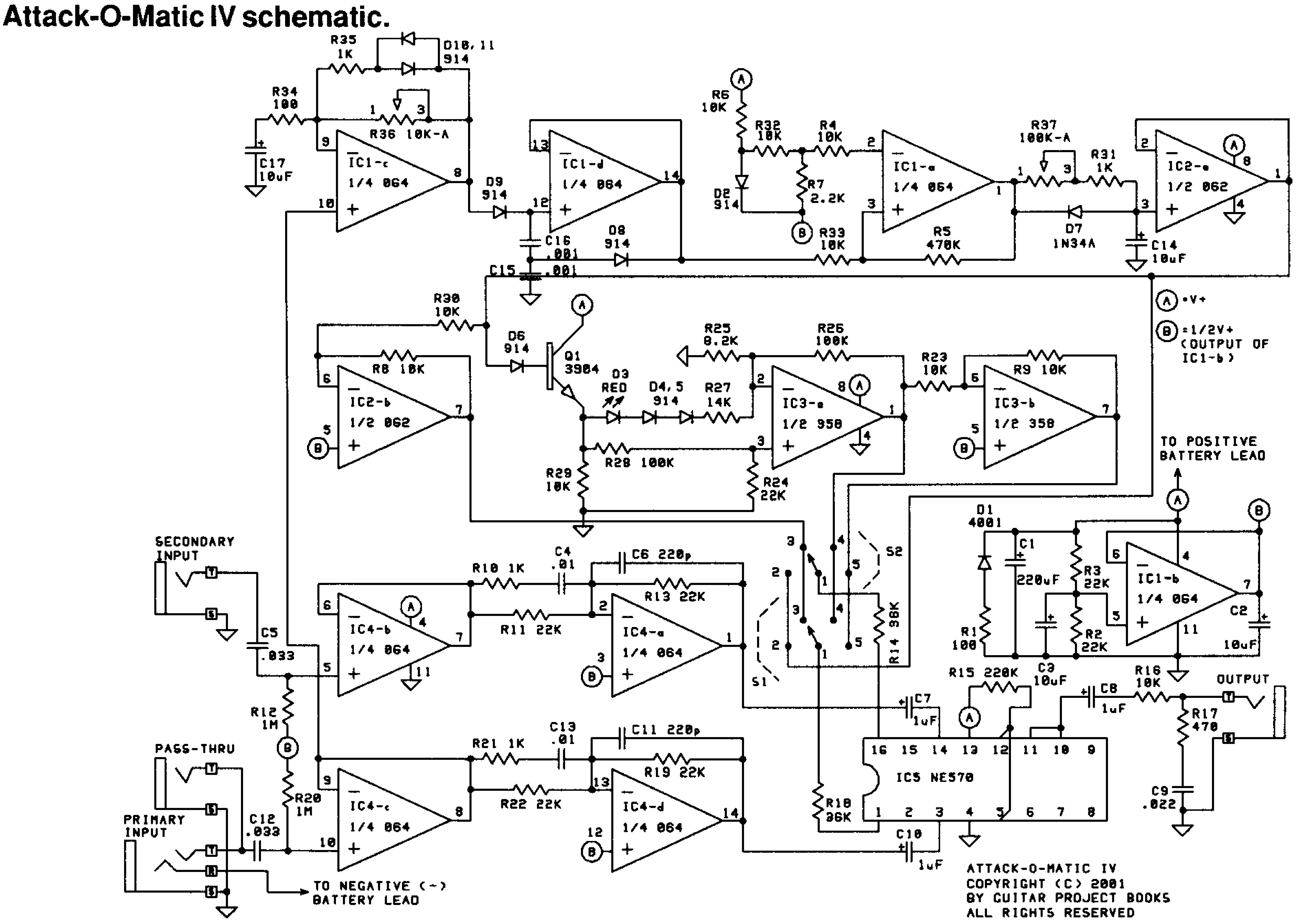
Several compromises were necessary to squeeze the circuit onto a single UCB: (1) neither preamp input contains the usual RF shunt network; (2) the nonlinear transfer block generates audible reset pulses under some playing conditions; (3) the bias of IC3-b (pin-5) should ideally be one or two diode drops below 1/2V+.

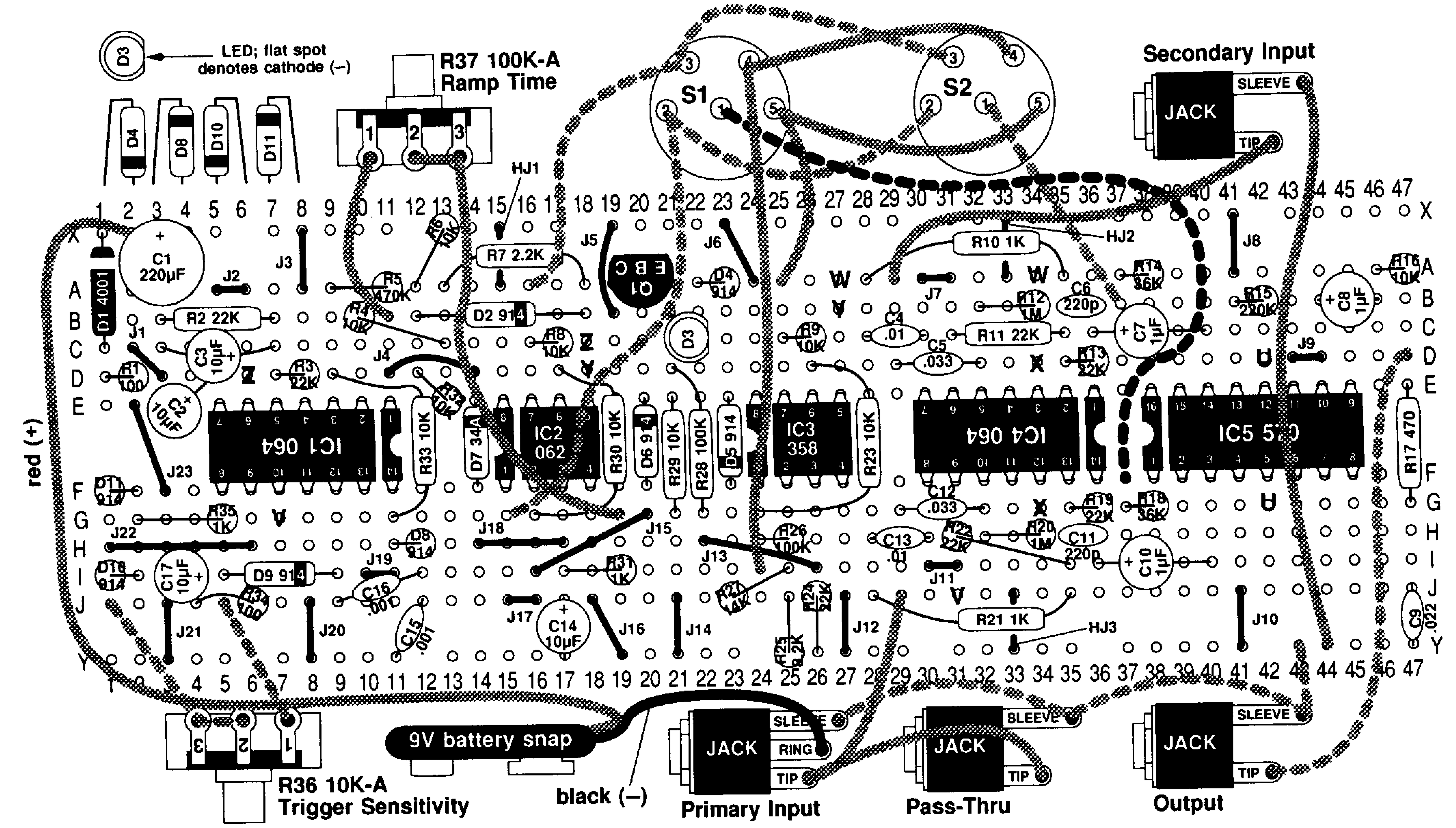
The prototype drew just under 8 milliamps. Do not substitute for the LM358. Because 14K is not a standard resistance value, realize it by wiring resistors in series, e.g., 10K with 3.9K. If a visual control indicator is desired, D3 may be mounted on the stompbox case.

The circuit is designed to reset instantly when the player mutes the strings; the muting need not be full for reset to occur.

This box applies four different gain envelopes to two feeds, further varied in ramp time that ranges from imperceptibly fast to about two seconds. These actions, as far as the Editor is aware, have never been duplicated in a commercial product.

Attack-O-Matic IV schematic.





Attack-O-Matic IV layout & wiring diagram.

Parts List/Soldering Checklist

Circuit Board Radio Shack p/n 276-170; Hosfelt p/n 42-183; or DC Electronics p/n J4-404

IC Sockets
- [ ] 14-pin for IC1; pin-1 to E11
- [ ] 8-pin for IC2; pin-1 to F15
- [ ] 8-pin for IC3; pin-1 to F24
- [ ] 14-pin for IC4; pin-1 to E36
- [ ] 16-pin for IC5; pin-1 to F38

Resistors

[ ]	R1	100	(brn-blk-brn)	D1-D2
[ ]	R2	22K	(red-red-org)	B3-B7
[ ]	R3	22K	(red-red-org)	D7-D8
[ ]	R4	10K	(brn-blk-org)	B10-C13
[ ]	R5	470K	(yel-vio-yel)	A9-A11
[ ]	R6	10K	(brn-blk-org)	X13-A12
[ ]	**[install hidden jumper HJ1 (X15-A15) before soldering R7]**			
[ ]	R7	2.2K	(red-red-red)	A13-A18
[ ]	R8	10K	(brn-blk-org)	C16-C17
[ ]	R9	10K	(brn-blk-org)	C25-C26
[ ]	**[install hidden jumper HJ2 (X33-A33) before soldering R10]**			
[ ]	R10	1K	(brn-blk-red)	A28-A35
[ ]	R11	22K	(red-red-org)	C31-C35
[ ]	R12	1M	(brn-blk-grn)	B32-B34
[ ]	R13	22K	(red-red-org)	D35-D36
[ ]	R14	36K	(org-blu-org)	A37-A38
[ ]	R15	220K	(red-red-yel)	B41-B42
[ ]	R16	10K	(brn-blk-org)	A46-A47
[ ]	R17	470	(yel-vio-brn)	E47-G47
[ ]	R18	36K	(org-blu-org)	G37-G38
[ ]	R19	22K	(red-red-org)	G35-G36
[ ]	R20	1M	(brn-blk-grn)	H32-H34
[ ]	**[install hidden jumper HJ3 (J33-Y33)) before soldering R21]**			
[ ]	R21	1K	(brn-blk-red)	J28-J35
[ ]	R22	22K	(red-red-org)	H31-I35
[ ]	R23	10K	(brn-blk-org)	D26-G24
[ ]	R24	22K	(red-red-org)	J26-Y26
[ ]	R25	8.2K	(gry-red-red)	J25-Y25
[ ]	R26	100K	(brn-blk-yel)	H24-H25
[ ]	R27	14K	(brn-yel-red)	J23-I25
[ ]	R28	100K	(brn-blk-yel)	D21-G22
[ ]	R29	10K	(brn-blk-org)	E21-G21
[ ]	R30	10K	(brn-blk-org)	D17-G16
[ ]	R31	1K	(brn-blk-red)	I17-I19
[ ]	R32	10K	(brn-blk-org)	D12-E13
[ ]	R33	10K	(brn-blk-org)	D9-G11
[ ]	R34	100	(brn-blk-brn)	J4-J6
[ ]	R35	1K	(brn-blk-red)	G2-G5

Bare Wire Jumpers

[ ]	J1	C2-D3
[ ]	J2	A5-A6
[ ]	J3	X8-A8
[ ]	J4	D11-D14
[ ]	J5	X19-B19
[ ]	J6	X23-A24
[ ]	J7	A30-A31
[ ]	J8	X41-A41
[ ]	J9	D43-D44
[ ]	J10	J41-Y41
[ ]	J11	I30-I31
[ ]	J12	J27-Y27
[ ]	J13	H22-I26
[ ]	J14	J21-Y21
[ ]	J15	I16-G20
[ ]	J16	J18-Y19
[ ]	J17	J15-J16
[ ]	J18	H14-H17
[ ]	J19	I10-I11
[ ]	J20	J8-Y8
[ ]	J21	J3-Y3
[ ]	J22	H1-H6
[ ]	J23	E2-F3

Capacitors

[ ]	C1	220µF	X3-A3 (+ lead to X3)
[ ]	C2	10µF	D5-E3 (+ lead to D5)
[ ]	C3	10µF	C3-C7 (+ lead to C7)
[ ]	C4	0.01	C28-C30
[ ]	C5	0.033	D29-D32
[ ]	C6	220pF	B35-B36
[ ]	C7	1µF	C36-C40 (+ lead to C36)
[ ]	C8	1µF	B44-B46 (+ lead to B44)
[ ]	C9	0.022	J47-Y47
[ ]	C10	1µF	I36-I40 (+ lead to I36)
[ ]	C11	220pF	H35-H36
[ ]	C12	0.033	G29-G32
[ ]	C13	0.01	H28-H30
[ ]	C14	10µF	J17-Y17
[ ]	C15	0.001	J12-Y11
[ ]	C16	0.001	I12-J9
[ ]	C17	10µF	I3-I4 (+ lead to I4)

Flying Jumpers (insulated wire)

[ ]	UU	D42-G42
[ ]	VV	G7-J31
[ ]	WW	A27-A34
[ ]	XX	D34-G34
[ ]	YY	D18-B27
[ ]	ZZ	D6-C18

Semiconductors

[ ]	D1	1N4001	X1-C1 (banded end to X1)
[ ]	D2	1N914	B12-B18 (banded end to B18)
[ ]	D3	red LED	C21-C22 (cathode to C22))
[ ]	D4	1N914	A22-A23 (banded end to A23)
[ ]	D5	1N914	E23-F23 (banded end to F23)
[ ]	D6	1N914	E20-F20 (banded end to E20)
[ ]	D7	1N34A	E14-F14 (banded end to E14)
[ ]	D8	1N914	H11-H12 (banded end to H11)
[ ]	D9	1N914	I5-I9 (banded end to I9)
[ ]	D10	1N914	I1-I2 (banded end to I1)
[ ]	D11	1N914	F1-F2 (banded end to F2)
[ ]	IC1	TL064 quad op amp; pin-1 to E11	
[ ]	IC2	TL062 dual op amp; pin-1 to F15	
[ ]	IC3	LM358 dual op amp; pin-1 to F24	
[ ]	IC4	TL064 quad op amp; pin-1 to E36	
[ ]	IC5	NE570; pin-1 to F38	
[ ]	Q1	2N3904; emitter (E) to A21, base (B) to A20, collector (C) to A19	

Potentiometers (T=terminal)
- [ ] R36 10K audio taper; T1 to J5, T2 to T3 and to J1
- [ ] R37 100K audio taper; T1 to B11, T2 to T3 and to G19

Jacks (T=terminal)
- [ ] primary input jack (1/4" 3-terminal/stereo): tip to tip of pass-thru jack and to J29, ring to black (–) battery lead, sleeve to Y43
- [ ] pass-thru jack (1/4" 2-terminal/mono): tip to tip of primary input jack, sleeve to Y43
- [ ] secondary input jack (1/4" 2-terminal/mono): tip to A29, sleeve to Y44
- [ ] output jack (1/4" 2-terminal/mono): tip to D47, sleeve to Y43

Switches (T=terminal)
- [ ] S1 (SP4T rotary switch): T1 to F37, T2 to G15, T3 to A16, T4 to I24, T5 to A25
- [ ] S2 (SP4T rotary switch): T1 to B37, T2 to G15, T3 to A16, T4 to I24, T5 to A25

9V Battery Leads
- [ ] black (–) lead to ring of primary input jack
- [ ] red (+) lead to X2

Project No. G343
Attack-O-Matic V

Triggered envelope drives dual-input crossfader.

Circuit Description

Signal Path: The primary input feed couples through C13-R19 to inverting amp IC2-d, whose gain is fixed at ~4.7. IC2-d's output couples to one input of a two-input crossfader comprised of IC3, IC4, and the associated components.

The secondary input couples to IC2-a, which is identical to IC2-d; IC2-a's output feeds the crossfader's other input.

Control Path: S1 selects between two trigger sources. One is the primary input, through terminal-3 of S1; the other is an external trigger jack, through terminal-1 of S1. S1's pole couples through C1-R1 to inverting amp IC1-b, whose gain varies by R27, varying the trigger threshold. IC1-b's output feeds integrator/auto-variable decay circuit IC1-c and associated components. IC1-c's output feeds a repetitive trigger circuit made up of IC1-d and associated components. IC1-d's output is normally low, flipping high for 50-80 milliseconds on receipt of a sufficiently large trigger impulse. Trigger output feeds a wave shaping network comprised of R21/22/26-D5/6-C16, buffered by follower IC2-c. R26 varies the decay time from ~50 milliseconds to about one second. IC2-c's output feeds unity-gain inverting amp IC2-b. The control path thus generates a triggered envelope, and an inverted version of that envelope.

The result of the control feeds interacting with the signal paths is to create a two-input crossfader that swaps the two input signals each time the trigger input exceeds threshold. R26 determines how fast the two swapped feeds return to their original channels. The setting of S1 determines whether the system triggers on the primary input, or on an external signal.

Use

Pots and switch have these function:

R26	envelope decay time
R27	trigger sensitivity
S1	trigger source select primary/external

Initial settings: R26 & R27 centered, S1: primary. Connect a guitar to the primary input; feed the pass-thru to a blatant effect, such as a distortion box, whose output feeds the secondary input. Connect outputs to two amps, or to two channels of a stereo amplifier; the wider the speaker separation, the more dramatic the effect. Pluck a single note and note that the two signals quickly swap sides, then return to their original sides more slowly. Adjust R27 if necessary to obtain a suitable threshold. Take R26 through its range and note the effect of varying the relaxation time.

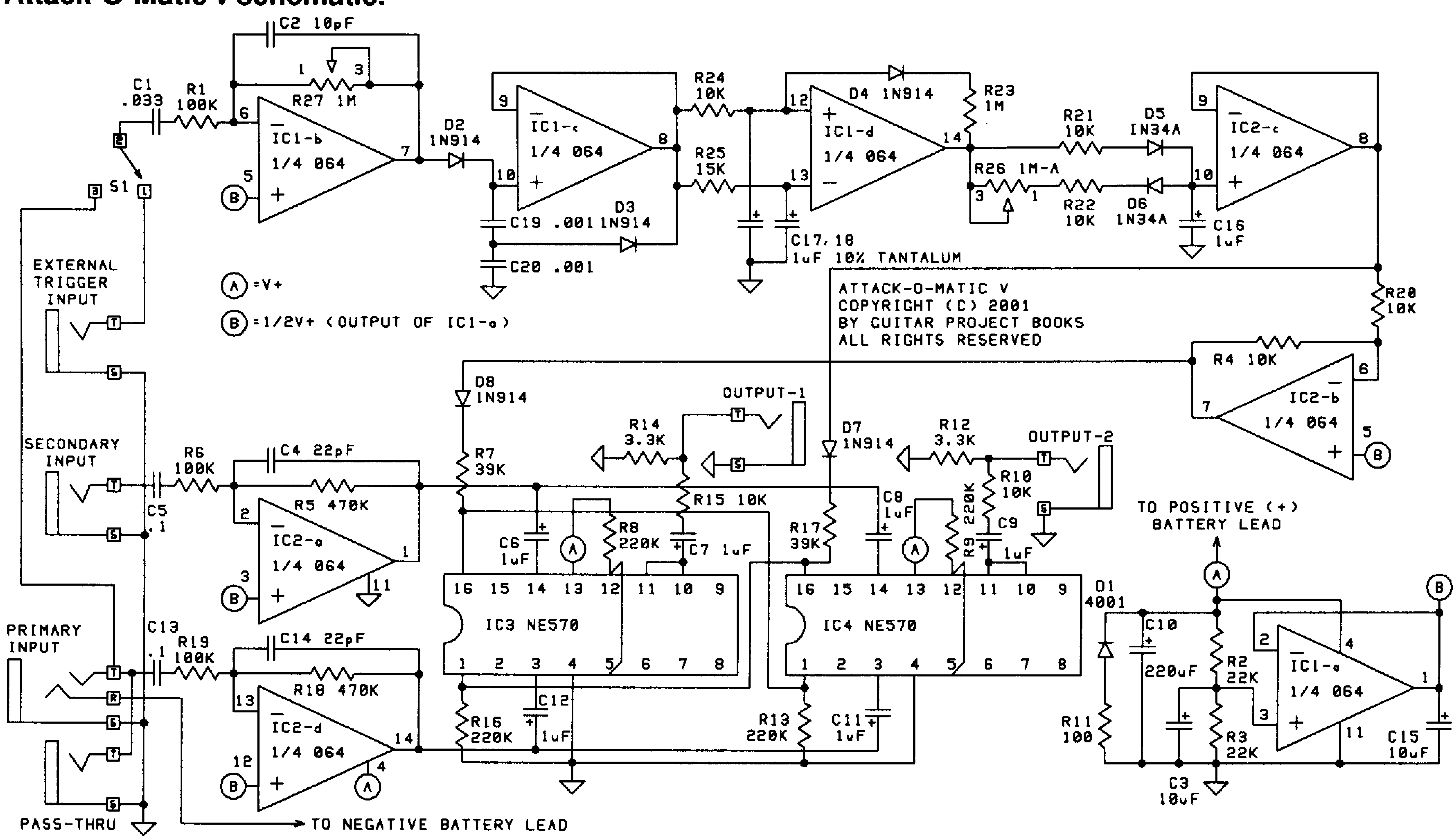
Notes

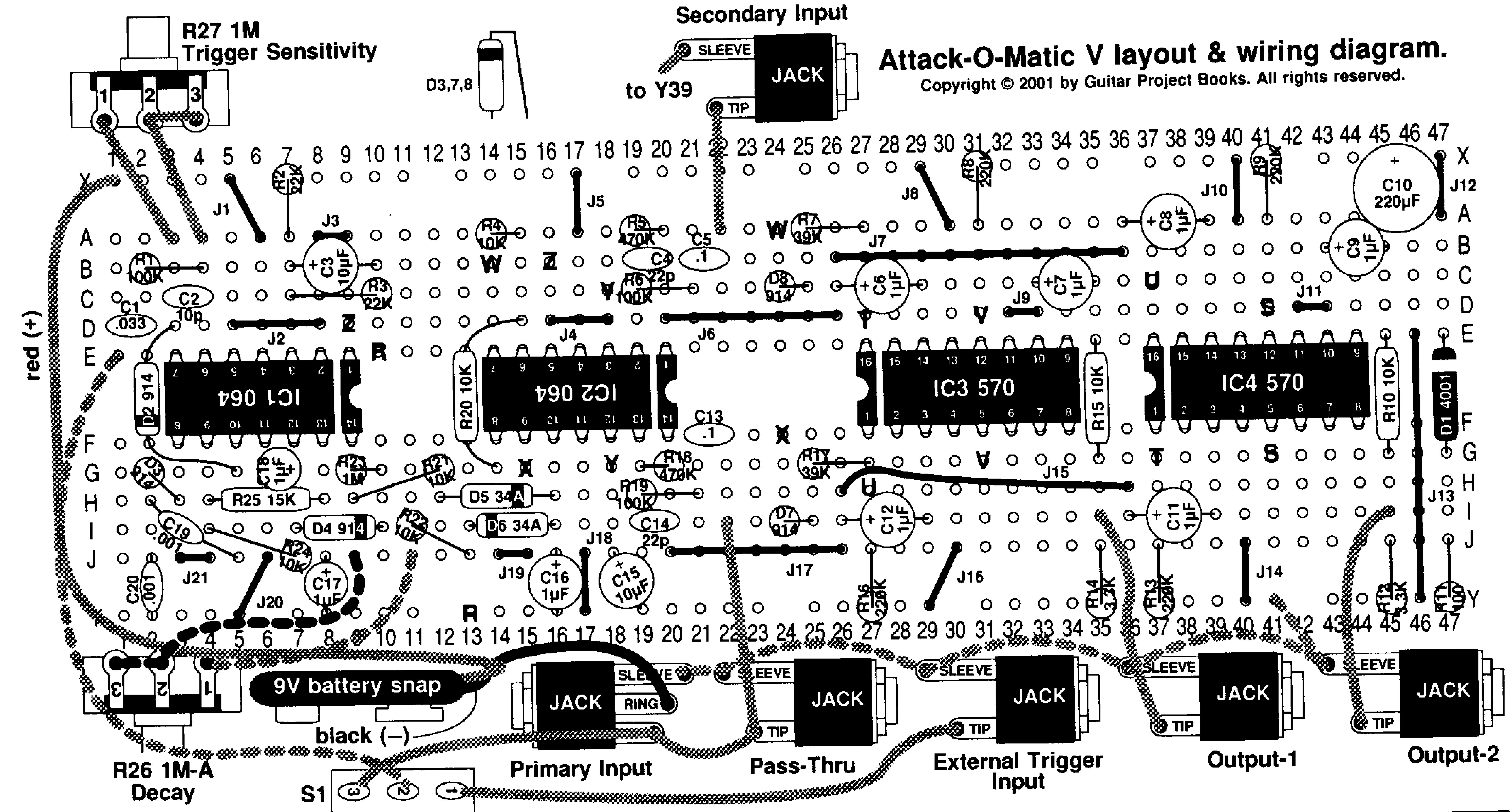
Attack-O-Matic V generates a stereo effect. The wider the separation of the two speakers or amps, the greater the impact. As with many novel effects, this one is easy to overdo. Some of the most gratifying effects result from using an external trigger. Establish to the audience that a distinctive sound emanates from each of two widely separated speakers, or from each channel in a mix. Then, on external trigger, these feeds swap, then return slowly to their original sides.

AOM5 generates a true triggered envelope whose timing and amplitude are independent of how hard the player picks, so long as the trigger exceeds threshold. The circuit can retrigger during decay. Trigger accuracy approaches 100% with single notes, whether muted or held. Chords, especially dissonant ones, are subject to multiple triggering that can be reduced by altering the setting of R27.

Like most effects with no commercial antecedent, this box benefits from careful, systematic experimentation to gauge its potential. The prototype drew 9.8 ma.

Attack-O-Matic V schematic.





Parts List/Soldering Checklist

Circuit Board Radio Shack p/n 276-170; Hosfelt p/n 42-183; or DC Electronics p/n J4-404

IC Sockets

- [ ] 14-pin for IC1; pin-1 to E9
- [ ] 14-pin for IC2; pin-1 to E20
- [ ] 16-pin for IC3; pin-1 to F27
- [ ] 16-pin for IC4; pin-1 to F37

Resistors

- [ ] R1 100K (brn-blk-yel) B2-B4
- [ ] R2 22K (red-red-org) X7-A7
- [ ] R3 22K (red-red-org) C7-C10
- [ ] R4 10K (brn-blk-org) A14-A15
- [ ] R5 470K (yel-vio-yel) A19-A20
- [ ] R6 100K (brn-blk-yel) C19-C21
- [ ] R7 39K (org-wht-org) A25-A27
- [ ] R8 220K (red-red-yel) X31-A31
- [ ] R9 220K (red-red-yel) X41-A41
- [ ] R10 10K (brn-blk-org) E45-G45
- [ ] R11 100 (brn-blk-brn) J47-Y47
- [ ] R12 3.3K (org-org-red) J45-Y45
- [ ] R13 220K (red-red-yel) J37-Y37
- [ ] R14 3.3K (org-org-red) J35-Y35
- [ ] R15 10K (brn-blk-org) E35-G35
- [ ] R16 220K (red-red-yel) J27-Y27
- [ ] R17 39K (org-wht-org) G25-G27
- [ ] R18 470K (yel-vio-yel) G19-G20
- [ ] R19 100K (brn-blk-yel) H19-H21
- [ ] R20 10K (brn-blk-org) D15-G14
- [ ] R21 10K (brn-blk-org) H9-G12
- [ ] R22 10K (brn-blk-org) I11-J13
- [ ] R23 1M (brn-blk-grn) G9-G10
- [ ] R24 10K (brn-blk-org) I4-J7
- [ ] R25 15K (brn-grn-org) H4-H8

Bare Wire Jumpers

- [ ] J1 X5-A6
- [ ] J2 D5-D8
- [ ] J3 A8-A9
- [ ] J4 D16-D18
- [ ] J5 X17-A17
- [ ] J6 D20-D26
- [ ] J7 B26-B36
- [ ] J8 X29-A30
- [ ] J9 D32-D33
- [ ] J10 X40-A40
- [ ] J11 D42-D43
- [ ] J12 X47-A47
- [ ] J13 E46-Y46
- [ ] J14 J40-Y40
- [ ] J15 H26-H36
- [ ] J16 J30-Y29
- [ ] J17 J20-J26
- [ ] J18 J17-Y17
- [ ] J19 J14-J15
- [ ] J20 J6-Y5
- [ ] J21 J3-J4

Capacitors

- [ ] C1 0.033 D1-D2
- [ ] C2 10pF C3-C4
- [ ] C3 10µF B7-B10 (+ lead to B7)
- [ ] C4 22pF B19-B20
- [ ] C5 0.1 B21-B22
- [ ] C6 1µF C26-C29 (+ lead to C26)
- [ ] C7 1µF C33-C35 (+ lead to C33)
- [ ] C8 1µF A36-A39 (+ lead to A36)
- [ ] C9 1µF B43-B45 (+ lead to B43)
- [ ] C10 220µF X46-A46 (+ lead to X46)
- [ ] C11 1µF I36-I39 (+ lead to I36)
- [ ] C12 1µF I26-I29 (+ lead to I26)
- [ ] C13 0.1 F21-F22
- [ ] C14 22pF I19-I20
- [ ] C15 10µF J18-Y19 (+ lead to J18)
- [ ] C16 1µF J16-Y16 (+ lead to J16)
- [ ] C17 1µF, 10% tantalum J8-Y8 (+ lead to J8)
- [ ] C18 1µF, 10% tantalum G6-G7 (+ lead to G7)
- [ ] C19 0.001 H2-J5
- [ ] C20 0.001 J2-Y2

Flying Jumpers (<u>insulated</u> wire)

- [ ] RR E10-Y13
- [ ] SS D41-G41
- [ ] TT D27-G37
- [ ] UU H27-C37
- [ ] VV D31-G31
- [ ] WW B14-A24
- [ ] XX G15-F24
- [ ] YY C18-G18
- [ ] ZZ D9-B16

Semiconductors

- [ ] D1 1N4001 E47-G47 (banded end to E47)
- [ ] D2 1N914 D3-G5 (banded end to G5)
- [ ] D3 1N914 G2-H3 (banded end to H3)
- [ ] D4 1N914 I7-I10 (banded end to I10)
- [ ] D5 1N34A H12-H16 (banded end to H16)
- [ ] D6 1N34A I13-I16 (banded end to I13)
- [ ] D7 1N914 I24-I25 (banded end to I25)
- [ ] D8 1N914 C24-C25 (banded end to C25)
- [ ] IC1 TL064 quad op amp; pin-1 to E9
- [ ] IC2 TL064 quad op amp; pin-1 to E20
- [ ] IC3 NE570; pin-1 to F27
- [ ] IC4 NE570; pin-1 to F37

Potentiometers (T=terminal)

- [ ] R26 1M audio taper T1 to J11, T2 to T3 and to J9
- [ ] R27 1M T1 to A3, T2 to T3 and to A4

Jacks (T=terminal)

- [ ] primary input jack (1/4" 3-terminal/stereo): tip to tip of pass-thru jack and to T3 of S1 and to I22, ring to black (–) battery lead, sleeve to Y41
- [ ] pass-thru jack (1/4" 2-terminal/mono): tip to tip of primary input jack, sleeve to Y41
- [ ] external trigger input jack (1/4" 2-terminal /mono): tip to T1 of S1, sleeve to Y41
- [ ] output-1 jack (1/4" 2-terminal/mono): tip to I35, sleeve to Y41
- [ ] output-2 jack (1/4" 2-terminal/mono): tip to I45, sleeve to Y41
- [ ] secondary input jack (1/4" 2-terminal/mono): tip to A22, sleeve to Y39

Switches (T=terminal)

- [ ] S1 (SPDT slide or toggle switch): T1 to tip of external trigger input jack, T2 to E1, T3 to tip of primary input jack

9V Battery Leads

- [ ] black (–) lead to ring of primary input jack
- [ ] red (+) lead to X1

Project No. G344
Attack-O-Matic VIII

Tandem version of Attack-O-Matic: two independent, linear ramps triggered by one input, driving two separate signal paths.

Circuit Function

Signal Path: The axe feed (primary input) couples through C10-R25 to inverting preamp IC2-d, whose gain is fixed at 4.7, and whose output couples through C9 to a VCA made up of half of IC3 and the associated components. This VCA's output is taken at pin-7 and couples through C8-R20-R21 to the primary output path. (The unprocessed primary input is available at the pass-thru jack.)

The secondary input follows a functionally identical path consisting of IC2-a and its associated components, and the VCA formed by the other half of IC3. The secondary output is taken at the juncture of R18-R19.

Both signal paths are noninverting; both paths incorporate 12 dB of quasi-companding noise reduction.

Control Path: IC2-d's output couples to noninverting modified log amp IC1-c, whose gain varies 0–40 dB under control of pot R32. IC1-c drives an indefinite interval generator consisting of IC1-a and -d and the associated components. The interval drives two separate, variable, linear ramp generators consisting of IC2-a and the associated components; and IC2-c and its associated components. The ramp output of IC2-b controls the gain of the secondary input's VCA through D4-R15; the ramp output of IC2-c controls gain of the primary input through D5-R24.

Use

Pots have these functions:

R32	trigger sensitivity
R33	secondary ramp time
R34	primary ramp time

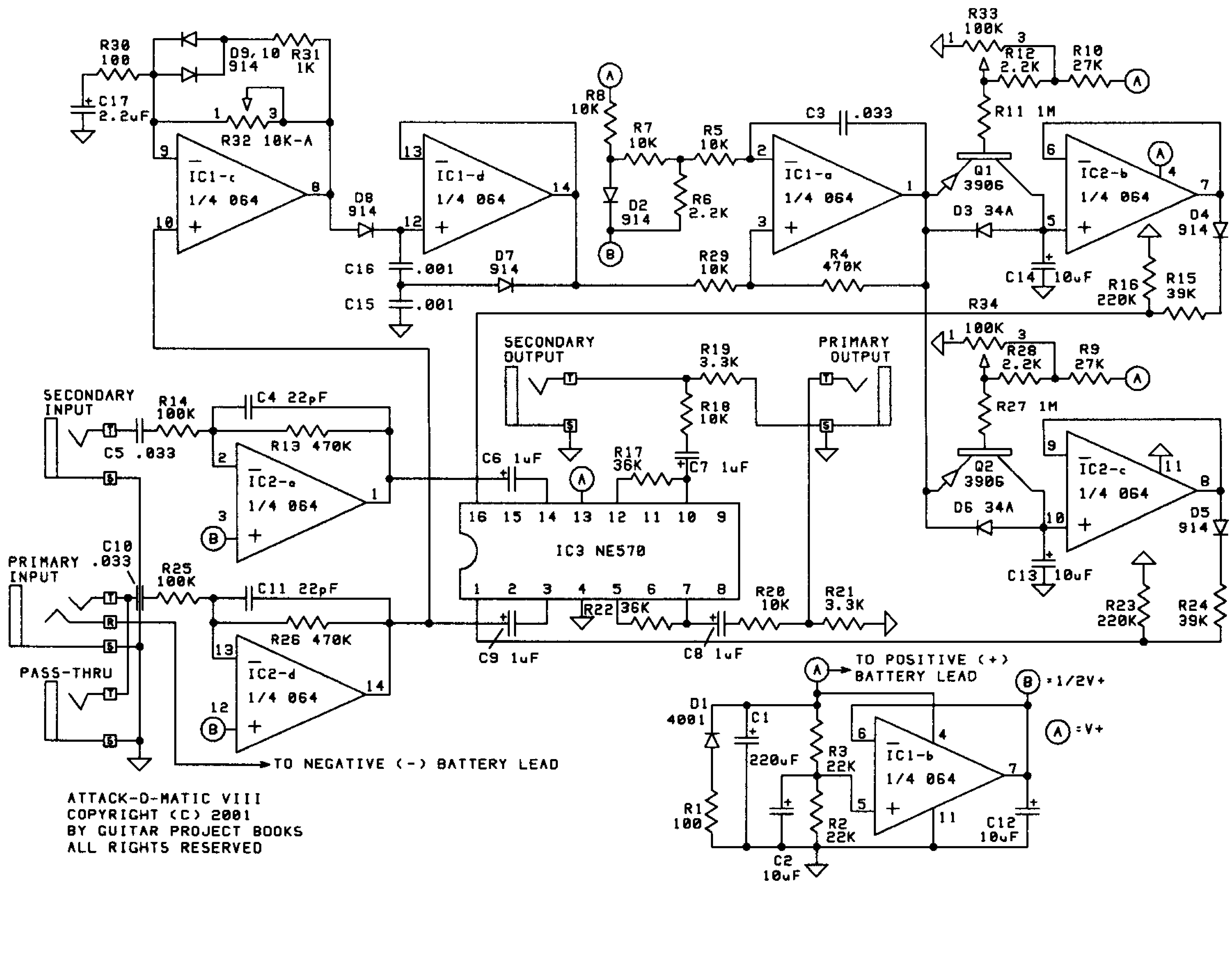
Initial settings: all pots centered. Connect axe to primary input, connect primary output to an amp; establish desired listening level. In this state a delay of about 200 milliseconds accompanies each new note or chord. Trim trigger sensitivity if necessary; take R34 through its range and note the attack times possible. Next, connect an axe cord between the pass-thru jack and the secondary input jack; move the output cord to the secondary output jack. Repeat the checkout sequence, using R33 to vary secondary ramp time.

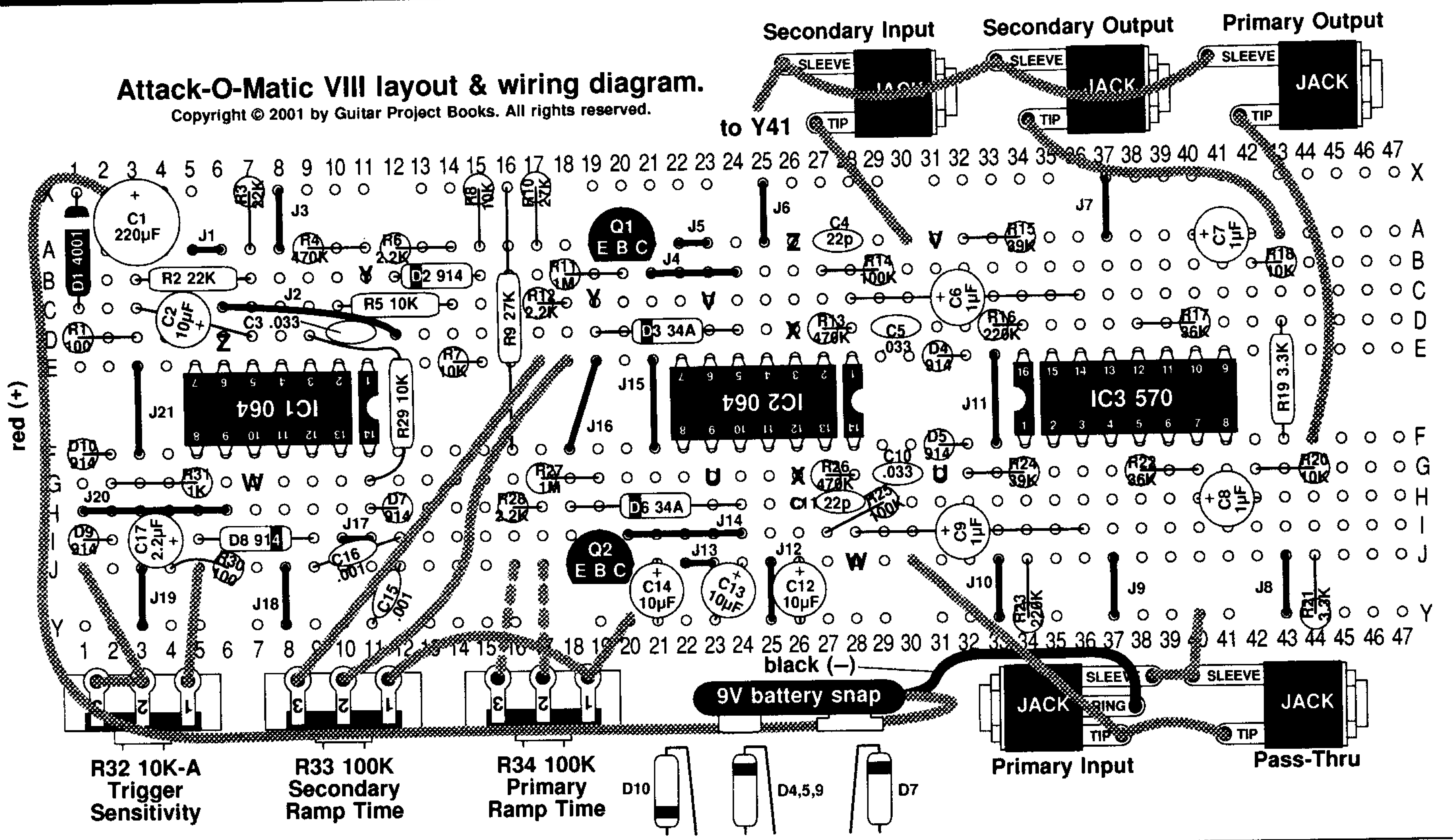
Next, connect the two outputs to separate amps, or to different channels of a stereo amp; and connect two different instruments to the inputs; or feed the pass-thru to a blatant effect, such as a distortion box, whose output comes in through the secondary input. Repeat the checkout sequence.

Notes

AOM8 illustrates how easily novel effects can be achieved using very simple circuit blocks, here a couple of linear ramps driven off a single indefinite interval.

Attack-O-Matic VIII schematic.





Attack-O-Matic VIII layout & wiring diagram.

Parts List/Soldering Checklist

Circuit Board Radio Shack p/n 276-170; Hosfelt p/n 42-183; or DC Electronics p/n J4-404

IC Sockets

- [ ] 14-pin for IC; pin-1 to E11
- [ ] 14-pin for IC; pin-1 to E28
- [ ] 16-pin for IC; pin-1 to F34

Resistors

- [ ] R1 100 (brn-blk-brn) D1-D3
- [ ] R2 22K (red-red-org) B3-B7
- [ ] R3 22K (red-red-org) X7-A7
- [ ] R4 470K (yel-vio-yel) A9-A11
- [ ] R5 10K (brn-blk-org) C10-C14
- [ ] R6 2.2K (red-red-red) A12-A14
- [ ] R7 10K (brn-blk-org) E14-E15
- [ ] R8 10K (brn-blk-org) X15-A15
- [ ] R9 27K (red-vio-org) X16-F16
- [ ] R10 27K (red-vio-org) X17-A17
- [ ] R11 1M (brn-blk-grn) B18-B20
- [ ] R12 2.2K (red-red-red) C17-C18
- [ ] R13 470K (yel-vio-yel) D27-D28
- [ ] R14 100K (brn-blk-yel) B27-B29
- [ ] R15 39K (org-wht-org) A32-A34
- [ ] R16 220K (red-red-yel) D33-D34
- [ ] R17 36K (org-blu-org) D38-D40
- [ ] R18 10K (brn-blk-org) B42-B43
- [ ] R19 3.3K (org-org-red) D43-F43
- [ ] R20 10K (brn-blk-org) G42-G44
- [ ] R21 3.3K (org-org-red) J44-Y44
- [ ] R22 36K (org-blu-org) G38-G40
- [ ] R23 220K (red-red-yel) J34-Y34
- [ ] R24 39K (org-wht-org) G32-G34
- [ ] R25 100K (brn-blk-yel) I27-H29
- [ ] R26 470K (yel-vio-yel) G27-G28
- [ ] R27 1M (brn-blk-grn) G17-G19
- [ ] R28 2.2K (red-red-red) H16-H17
- [ ] R29 10K (brn-blk-org) D9-G11
- [ ] R30 100 (brn-blk-brn) J4-J6
- [ ] R31 1K (brn-blk-red) G2-G5

Bare Wire Jumpers

- [ ] J1 A5-A6
- [ ] J2 C6-D12
- [ ] J3 X8-A8
- [ ] J4 B21-B24
- [ ] J5 A22-A23
- [ ] J6 X25-A25
- [ ] J7 X37-A37
- [ ] J8 J43-Y43
- [ ] J9 J37-Y37
- [ ] J10 J33-Y33
- [ ] J11 E33-F33
- [ ] J12 J25-Y25
- [ ] J13 J22-J23
- [ ] J14 I20-I24
- [ ] J15 E21-F21
- [ ] J16 E19-F18
- [ ] J17 I10-I11
- [ ] J18 J8-Y8
- [ ] J19 J3-Y3
- [ ] J20 H1-H6
- [ ] J21 E3-F3

Capacitors

- [ ] C1 220µF X3-A3 (+ lead to X3)
- [ ] C2 10µF C3-D7 (+ lead to D7)
- [ ] C3 0.033 D10-D11
- [ ] C4 22pF A27-A28
- [ ] C5 0.033 D29-D30
- [ ] C6 1µF C28-C36 (+ lead to C28)
- [ ] C7 1µF A40-A42 (+ lead to A40)
- [ ] C8 1µF H40-H42 (+ lead to H40)
- [ ] C9 1µF I28-I36 (+ lead to I28)
- [ ] C10 0.033 G29-G30
- [ ] C11 22pF H27-H28
- [ ] C12 10µF J26-Y26 (+ lead to J26)
- [ ] C13 10µF J24-Y23 (+ lead to J24)
- [ ] C14 10µF J21-Y21 (+ lead to J21)
- [ ] C15 0.001 J12-Y11
- [ ] C16 0.001 J9-I12
- [ ] C17 2.2µF I3-I4 (+ lead to I4)

Flying Jumpers (insulated wire)

- [ ] UU G23-G31
- [ ] VV C23-A31
- [ ] WW G7-J28
- [ ] XX D26-G26
- [ ] YY B11-C19
- [ ] ZZ D6-A26

Semiconductors

- [ ] D1 1N4001 X1-C1 (banded end to X1)
- [ ] D2 1N914 B12-B15 (banded end to B12)
- [ ] D3 1N34A D19-D24 (banded end to D19)
- [ ] D4 1N914 E31-E32 (banded end to E32)
- [ ] D5 1N914 F31-F32 (banded end to F32)
- [ ] D6 1N34A H18-H24 (banded end to H18)
- [ ] D7 1N914 H11-H12 (banded end to H11)
- [ ] D8 1N914 I5-I9 (banded end to I9)
- [ ] D9 1N914 I1-I2 (banded end to I2)
- [ ] D10 1N914 F1-F2 (banded end to F1)
- [ ] IC1 TL064 quad op amp; pin-1 to E11
- [ ] IC2 TL-64 quad op amp; pin-1 to E28
- [ ] IC3 NE570; pin-1 to F34
- [ ] Q1 2N3906; emitter (E) to A19, base (B) to A20, collector (C) to A21
- [ ] Q2 2N3906; emitter (E) to J18, base (B) to J19, collector (C) to J20

select Q1 & Q2 for beta = 150, ±10

Potentiometers (T=terminal)

- [ ] R32 10K audio taper T1 to J5, T2 to T3 and to J1
- [ ] R33 100K T1 to Y20, T2 to E18, T3 to E17
- [ ] R34 100K T1 to Y20, T2 to J17, T3 to J16

Jacks (T=terminal)

- [ ] primary input jack (1/4" 3-terminal/stereo): tip to tip of pass-thru jack and to J30, ring to negative (–) battery lead, sleeve to Y40
- [ ] pass-thru jack (1/4" 2-terminal/mono): tip to tip of primary input jack, sleeve to Y40
- [ ] secondary input jack (1/4" 2-terminal/mono): tip to A30, sleeve to Y41
- [ ] secondary output jack (1/4" 2-terminal mono): tip to A43, sleeve to Y41
- [ ] primary output jack (1/4" 2-terminal/mono): tip to F44, sleeve to Y41

9V Battery Leads

- [ ] black (–) lead to ring of primary input jack
- [ ] red (+) lead to X2

Project No. G345
Ratchet-O-Matic

Voltage controlled panner triggers on every note, every other note, or every fourth note.

Circuit Function

Signal Path: Axe feed couples through R7-C8 to voltage follower IC5-b, whose output couples through treble emphasis network R10-R11-C12 to inverting amp IC5-a, whose output couples through C14 and C13 to two inputs of voltage controlled panner IC4, one of whose outputs couples through C6 to treble de-emphasis network R6-R4-C5; and whose other output couples through C15 to treble de-emphasis network R12-R13-C17. One output is taken at the juncture of R4-R6; the other output at the juncture of R12-R13. The net signal paths are noninverting.

Control Path: The output of IC5-b couples through C1-R1 to inverting amp IC1-b, whose gain varies 0–10 under control of R23, which varies the trigger sensitivity. IC1-b's output couples to a fixed-interval generator comprised of IC1-c and -d, whose output couples through buffer Q1 to IC2, a 4013 configured as two divide-by-two circuits in series. S1 selects among three impulses: the raw output of buffer Q1, the ÷2 signal from IC2, or the ÷4 signal from IC2. S2 feeds the selected signal to the input of IC3, a 4017 configured as a divide-by-two counter. The result of this control path is that, when S1 selects position 4 (the output of Q1), pins 3 and 2 of IC3 swap high/low with each note. When S1 selects position 3 (the ÷2 output of IC2), pins 2 and 3 swap on every other note. When S1 selects position 2 (the ÷4 output of IC2), pins 2 and 3 swap on every fourth note.

Pin-2 of IC2 couples through R16 to pin-1 of IC4; pin-3 of IC3 couples through R15 to pin-16 of IC4. When one pin is high, the other is low, causing the outputs of IC4 to pan left-right, or the reverse.

Use

Pots and switch have these functions:

R23	trigger sensitivity
S1	trigger select ÷1/÷2/÷4

Initial settings: R23 centered, S1 in position 4 (fully CCW). Connect unit to axe and two amps, or to the left and right inputs of a stereo system. Establish desired listening level. In this state, the input signal should swap outputs with each note; which is to say, the first note emerges from output-1, the second note from output-2, and so forth. Adjust the trigger threshold if necessary to achieve desired sensitivity. Move S1 to position 3, and panning should occur every other note; every fourth note with S1 in position 2.

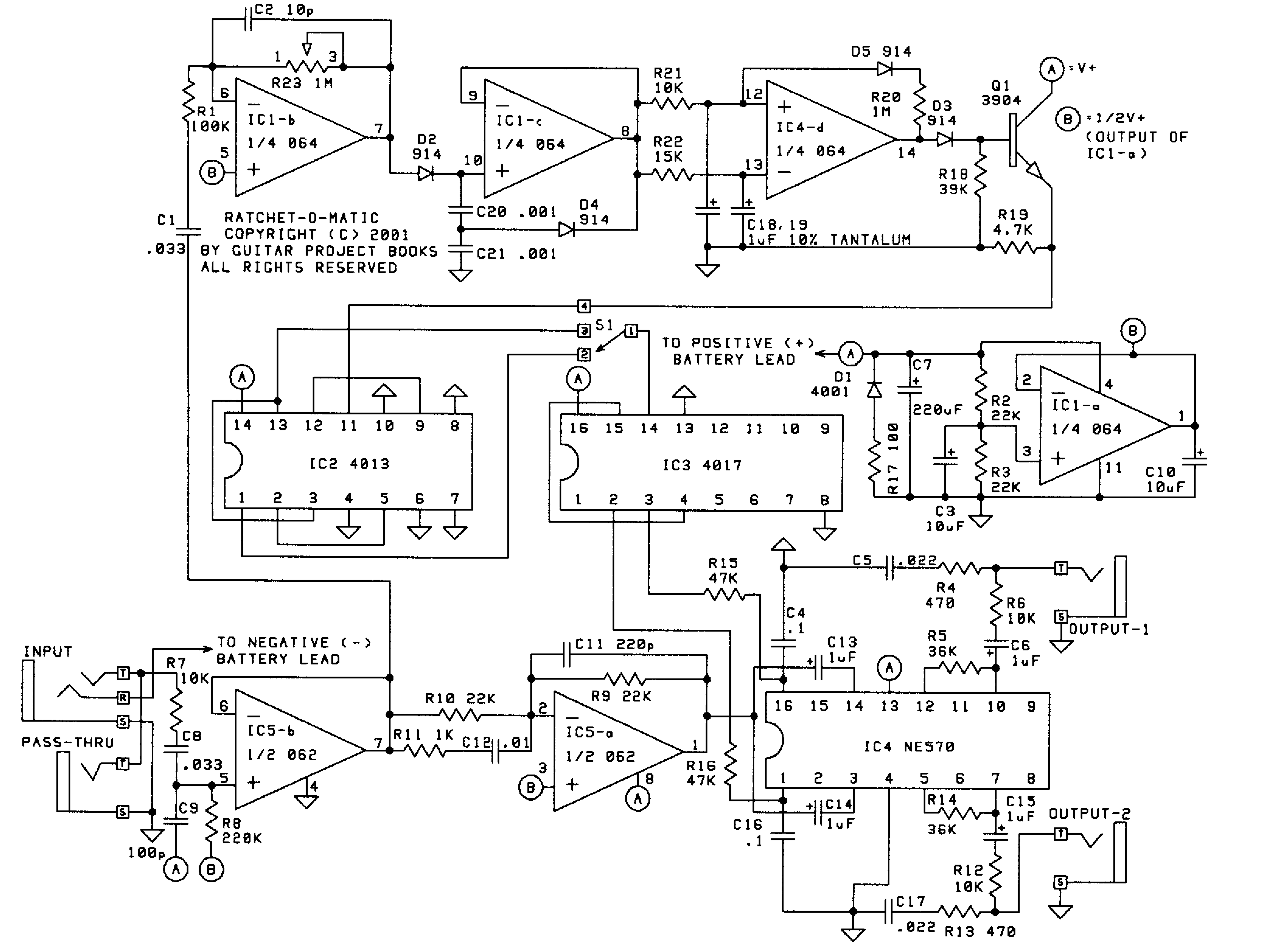
Notes

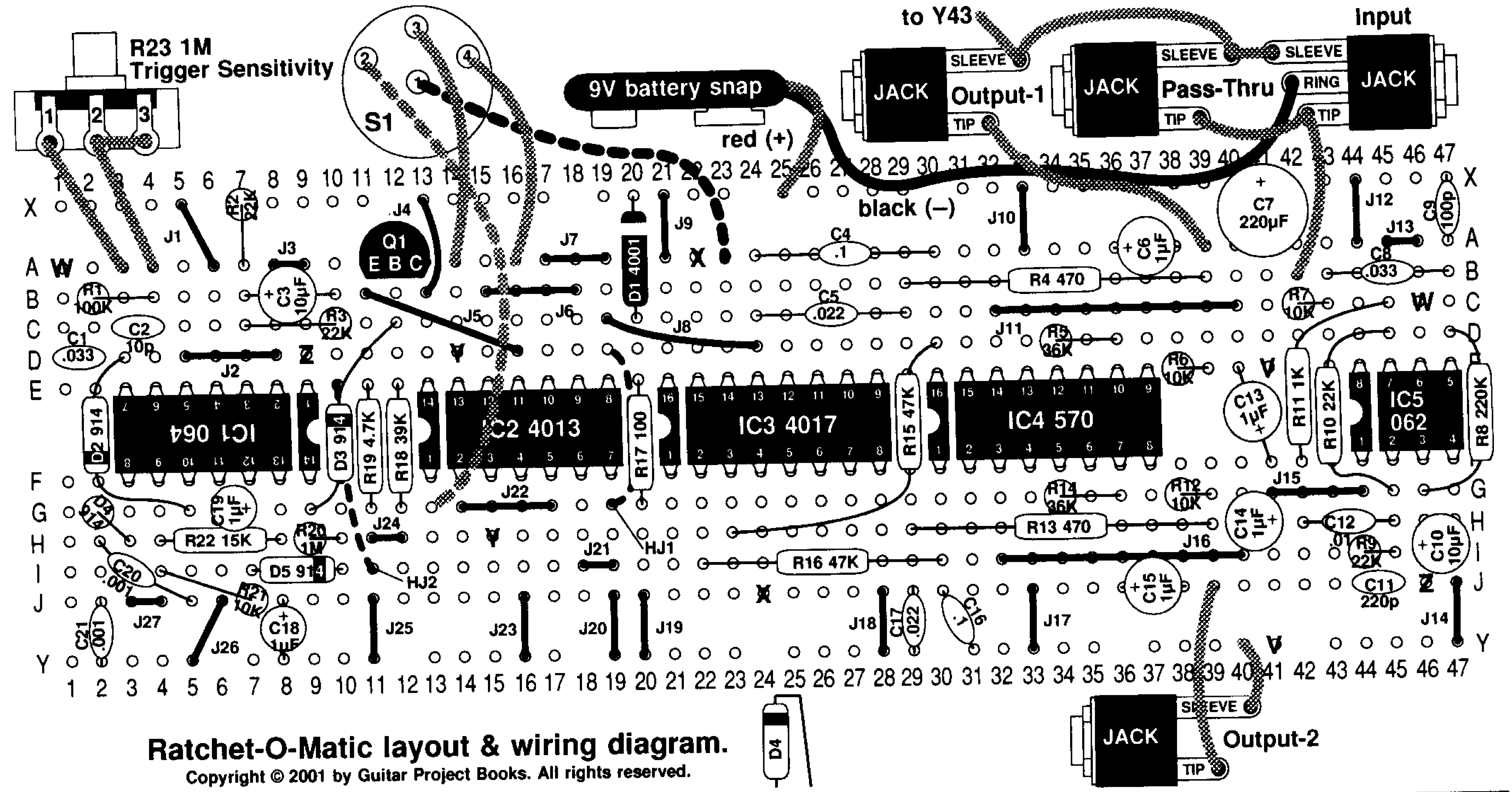
Trigger accuracy approaches 100% on single notes, whether muted or held. Chords, particularly dissonant ones, may cause false triggering, reduced by lowering trigger sensitivity. The 0.1µF values of C4 & C16 are nominal; their time constant with R15 & R16 determines panning speed. Use larger caps for gentler panning.

Ratchet-O-Matic is a special effect that retains impact through spare use; for example, to give a new dimension to the muted guitar part in *Pipeline.*

The prototype drew just under 6 ma.

Ratchet-O-Matic schematic.





Ratchet-O-Matic layout & wiring diagram.

Parts List/Soldering Checklist

Circuit Board Radio Shack p/n 276-170; Hosfelt p/n 42-183; or DC Electronics p/n J4-404

IC Sockets

[ ] 14-pin for IC1; pin-1 to E9
[ ] 14-pin for IC2; pin-1 to F13
[ ] 16-pin for IC3; pin-1 to F21
[ ] 16-pin for IC4; pin-1 to F30
[ ] 8-pin for IC5; pin-1 to F44

Resistors

[ ]	R1	100K	(brn-blk-yel)	B2-B4
[ ]	R2	22K	(red-red-org)	X7-A7
[ ]	R3	22K	(red-red-org)	C7-C10
[ ]	R4	470	(yel-vio-brn)	B29-B39
[ ]	R5	36K	(org-blu-org)	D34-D36
[ ]	R6	10K	(brn-blk-org)	E38-E39
[ ]	R7	10K	(brn-blk-org)	C42-C43
[ ]	R8	220K	(red-red-yel)	D47-G46
[ ]	R9	22K	(red-red-org)	I44-I45
[ ]	R10	22K	(red-red-org)	D45-G45
[ ]	R11	1K	(brn-blk-red)	C45-F42
[ ]	R12	10K	(brn-blk-org)	G38-G39
[ ]	R13	470	(yel-vio-brn)	H29-H39
[ ]	R14	36K	(org-blu-org)	G34-G36
[ ]	R15	47K	(yel-vio-org)	D30-H23
[ ]	R16	47K	(yel-vio-org)	I22-I30

[ ] solder hidden jumper HJ1 (D19-G19) before soldering R17

[ ]	R17	100	(brn-blk-brn)	E20-G20
[ ]	R18	39K	(org-wht-org)	E12-G12
[ ]	R19	4.7K	(yel-vio-red)	E11-G11
[ ]	R20	1M	(brn-blk-grn)	H9-H10
[ ]	R21	10K	(brn-blk-org)	I4-J7
[ ]	R22	15K	(brn-grn-org)	H4-H8

Bare Wire Jumpers

[ ]	J1	X5-A6
[ ]	J2	D5-D8
[ ]	J3	A8-A9
[ ]	J4	X13-B13
[ ]	J5	B11-D16
[ ]	J6	B15-B18
[ ]	J7	A17-A19
[ ]	J8	C19-D24
[ ]	J9	X21-A21
[ ]	J10	X33-A33
[ ]	J11	C32-C40
[ ]	J12	X44-A44
[ ]	J13	A45-A46
[ ]	J14	J47-Y47
[ ]	J15	G41-G44
[ ]	J16	I32-I40
[ ]	J17	J33-Y33
[ ]	J18	J28-Y28
[ ]	J19	J20-Y20
[ ]	J20	J19-Y19
[ ]	J21	I18-I19
[ ]	J22	G14-G17
[ ]	J23	J16-Y16
[ ]	J24	H11-H12
[ ]	J25	J11-Y11
[ ]	J26	J6-Y5
[ ]	J27	J3-J4

Capacitors

[ ]	C1	0.033	D1-D2
[ ]	C2	10pF	C3-C4
[ ]	C3	10µF	B7-B10 (+ lead to B7)
[ ]	C4	0.1	A24-A30
[ ]	C5	0.022	C24-C29
[ ]	C6	1µF	A36-A38 (+ lead to A36)
[ ]	C7	220µF	X41-A41 (+ lead to X41)
[ ]	C8	0.033	B43-B47
[ ]	C9	100pF	X47-A47
[ ]	C10	10µF	I46-I47 (+ lead to I46)
[ ]	C11	220pF	J44-J45
[ ]	C12	0.01	H42-H45
[ ]	C13	1µF	E40-F41 (+ lead to F41)
[ ]	C14	1µF	H40-H41 (+ lead to H41)
[ ]	C15	1µF	J36-J38 (+ lead to J36)
[ ]	C16	0.1	J30-Y31
[ ]	C17	0.022	J29-Y29
[ ]	C18	1µF, 10% tantalum	J8-Y8 (+ lead to J8)
[ ]	C19	1µF, 10% tantalum	G6-G7 (+ lead to G7)
[ ]	C20	0.001	H2-J5
[ ]	C21	0.001	J2-Y2

Flying Jumpers (<u>insulated</u> wire)

[ ]	VV	E41-Y41
[ ]	WW	A1-C46
[ ]	XX	A22-J24
[ ]	YY	D14-H15
[ ]	ZZ	D9-J46

Semiconductors

[ ] D1 1N4001 X20-C20 (banded end to X20)
[ ] D2 1N914 D3-G5 (banded end to G5)
[ ] solder hidden jumper HJ2 (E10-I11) before soldering D3
[ ] D3 1N914 C12-G9 (banded end to C12)
[ ] D4 1N914 G2-H3 (banded end to H3)
[ ] D5 1N914 I7-I10 (banded end to I10)
[ ] IC1 TL064 quad op amp; pin-1 to E9
[ ] IC2 4013; pin-1 to F13
[ ] IC3 4017; pin-1 to F21
[ ] IC4 NE570; pin-1 to F30
[ ] IC5 TL062 dual op amp; pin-1 to F44
[ ] Q1 2N3904 emitter (E) to A11, base (B) to A12, collector (C) to A13

Potentiometers (T=terminal)

[ ] R23 1M T1 to A3, T2 to T3 and to A4

Jacks (T=terminal)

[ ] input jack (1/4" 3-terminal/stereo): tip to tip of pass-thru jack and to B42, sleeve to Y43
[ ] pass-thru jack (1/4" 2-terminal/mono): tip to tip of input jack, sleeve to Y43
[ ] output-1 jack (1/4" 2-terminal/mono): tip to A39, sleeve to Y43
[ ] output-2 jack (1/4" 2-terminal/mono): tip to J39, sleeve to Y40

Switches (T=terminal)

[ ] S1 (SP3T rotary switch): T1 to A23, T2 to G13, T3 to A14, T4 to A16

9V Battery Leads

[ ] black (–) lead to ring of input jack
[ ] red (+) lead to X25

Beginner's View *(continued from page 3)*

(C1) is so large that leakage has negligible effect.

It's often useful, when working up envelope circuits, to test silicon and germanium diodes, because circuits that fail with one type may work with the other.

Q. What about nonlinear transfer—what you've called direction-changing ramps?

A. Fig. 1–7 shows one method, based on diodes' *forward drop*, the voltage at which the diode turns on, or becomes a low-resistance conduction path; ~1.8V for a red LED; ~0.6V for 1N914s. So the three series diodes in Fig. 1–7 have a net drop of (1.8V + 1.2V) = 3V. On A1's corresponding output curve, the breakpoint—the point at which the curve starts to change direction—occurs at an input voltage of about 3V.

Q. I still don't understand what's going on in Fig. 1–7.

A. As the input voltage rises from 0V to 3V, R3 acts as if it weren't in the circuit because the diodes don't conduct. Gain of A1 equals [1 + (R5÷R4)] = 13.2. At the same time, divider action of R1-R2 reduces the input voltage by a factor of [R2 ÷ (R1 + R2)] = 0.18. So the net gain applied to the input voltage is (0.18 x 13.2) = 2.4. The output of A1 rises 2.4 times as fast as the input voltage.

But once the input voltage exceeds 3V, R3 passes current—but R3 ties to A1's *inverting* input. Gain of this path equals –(R5÷R3) = –7.1. This is nearly three times the net gain of the noninverting path, so the output of A1 first slows its rise, then reverses direction, returning to ground as the input voltage reaches ~8V.

Q. Jumping ahead for a moment, I'm comparing Fig. 1–7 to a similar circuit in Attack-O-Matic IV; but in that latter circuit, the input voltage coming off an 06X op amp first passes through a diode (D6) and an emitter follower (Q1).

A. The point of those components is to take the resting input voltage essentially to 0V, or ground. The output of an 06X op amp can only swing within ~0.8V of ground. That voltage applied to the nonlinear transfer block gives an output of (0.8 x 2.4) = ~2V. We want the resting output of IC3-a in AOM4 to be near ground, so we insert voltage-dropping circuitry.

Q. Why not use an 06X op amp in place of IC3-a on the AOM4 schematic?

A. We could have, but doing so requires changes in the network components to account for the limited input/output range of 06X op amps.

Q. You've implied that's it's possible to have a nonlinear curve change direction more than once.

A. That's correct. Fig. 3 shows an example of a three-slope curve. Here component values and supply voltage stability become critical, for slight changes will upset the curve. The diodes' temperature coefficient could become significant under some conditions. Working up this type of circuit calls for a ramp generator and an oscilloscope, plus a reason to create such a function.

It's important to remember that direction-changing blocks work whether the input voltage is rising or falling. When the indefinite interval falls from its positive limit back to its negative limit, the output of the nonlinear block rises and falls. This generates something of a reset pulse that, depending on the circuit, may produce an audible pop or click. We accepted this drawback to simplify the design of AOM4.

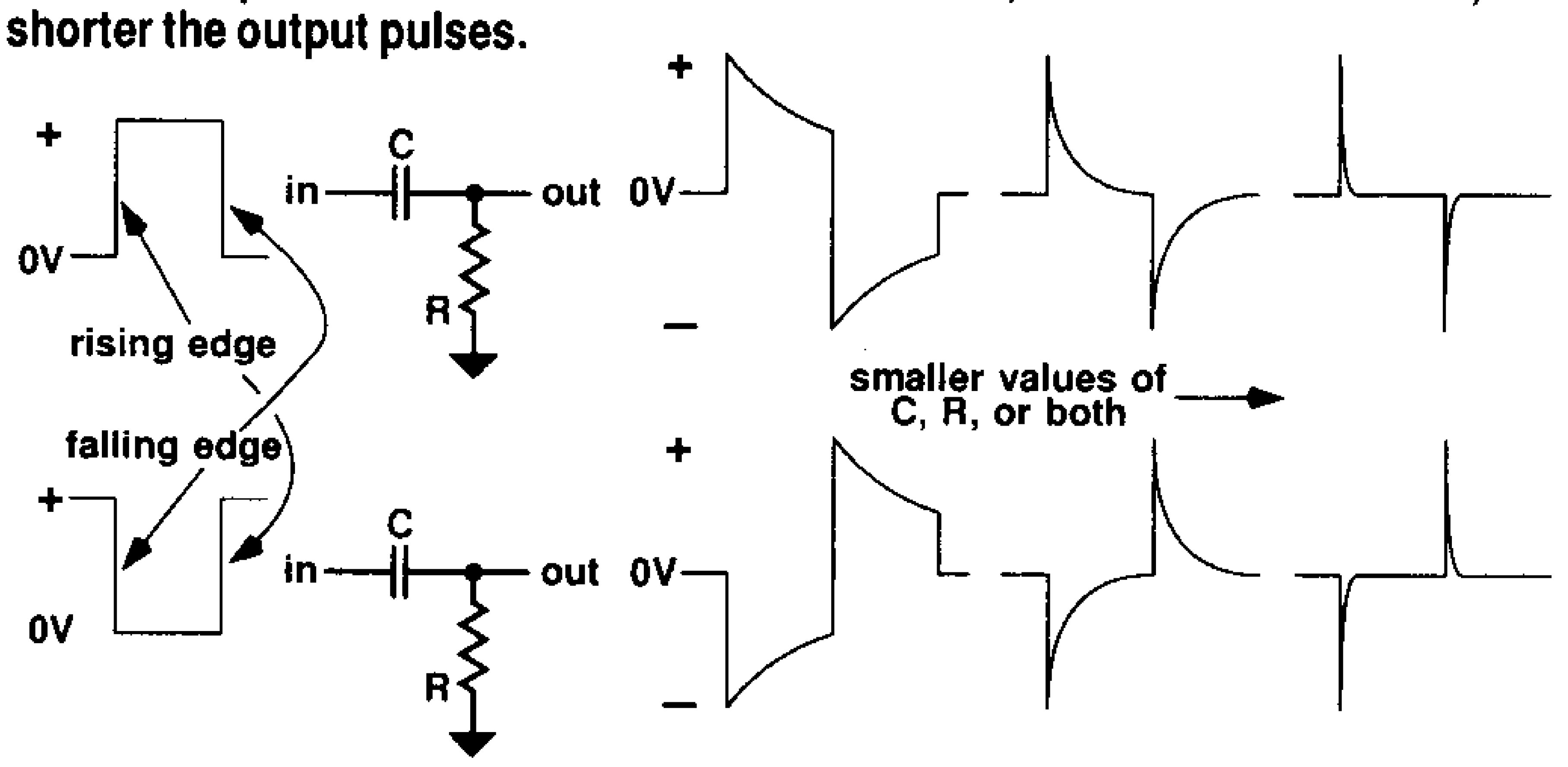
Q. How can I generate a triggered interval of fixed duration?

A. Refer to Fig. 1–8. The preamp and rectifier/integrator resemble those of Fig. 1–4. A3 is a comparator whose output is normally high. It flips low for 40–60 ms when triggered. The downward pulse is differentiated in C8——

Q. What does "differentiated in C8" mean? Specifically, what does the waveform look like after being "differentiated in C8"?

A. Check out Fig. 5. A capacitor and a resistor wired as shown make a

Fig. 5. Simplest differentiator consists of a cap shunted by a resistor. A positive pulse differentiated in such a network yields a positive output pulse from the rising edge, a true, negative pulse from the falling edge. Output shape and duration depend on the relative values of R and C; the smaller the values, the shorter the output pulses.



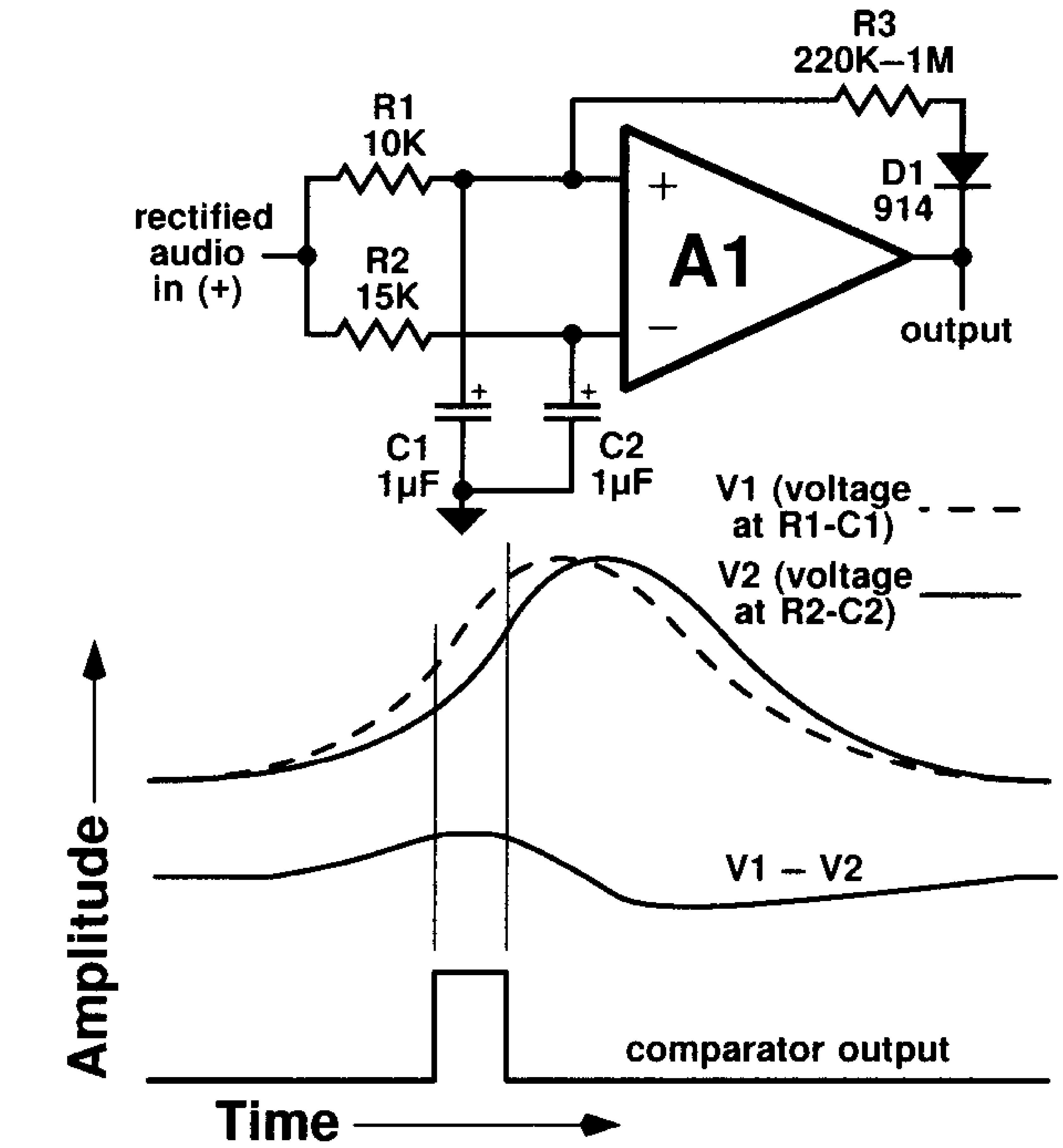
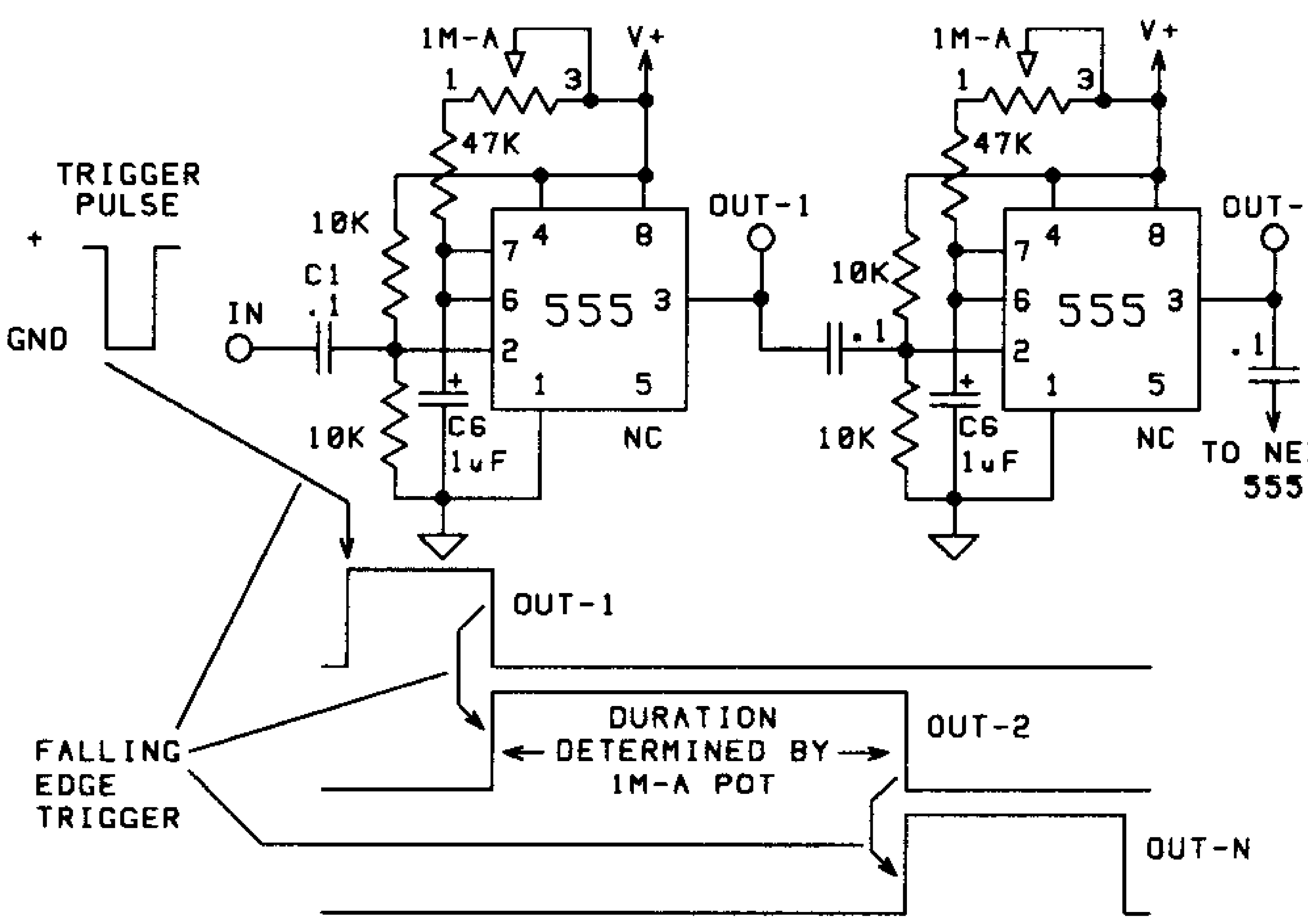


Fig. 6. Function of impulse trigger circuit becomes clear by examining voltage vs. time curves. V1, the voltage at the juncture of R1-C1, will always change faster than V2, the voltage at the juncture of R2-C2, because R1-C1 has a shorter time constant than R2-C2. Thus, when the input voltage is rising, V1 will always exceed V2, flipping the comparator output high. When the input voltage is falling, V1 will always be lower than V2, flipping the comparator output low. Directional hysteresis provided by R3-D1 prevents comparator from reacting to small voltage changes. By choosing subsonic corner frequencies for both RC pairs, the circuit gains significant ability to ignore ripple in the raw control input.

Fig. 7. Illustrates one approach to both delayed and sequential intervals. 555 timer chip is configured as a one-shot: a circuit that delivers a single output pulse on receipt of a trigger input, which is a negative pulse, differentiated in C1. Duration of 555's positive output pulse is determined by setting of 1M-A pot. When first output interval ends, its falling edge triggers second 555. Any number of 555s can be chained to give sequential intervals. To achieve a delayed interval, use only the output of the second 555 as the main interval; setting of first 1M-A pot determines delay from trigger to onset of interval.



simple differentiator.
Q. Looks like a simple highpass filter.
A. Yes: highpass filters are differentiators. If you apply a squarewave to the input, you get two distinct outputs. The output is a positive pulse from the rising edge of the input. The other output is a negative pulse that results from the falling edge of the input. The negative pulse is what we're after, because that triggers the 555 timer chip. Upon receipt of the negative trigger pulse—the chip ignores the positive pulse—pin-3 of the 555 flips high for a period determined by the setting of the 1M-A pot. Here that time ranges from 50 milliseconds to about 1.1 seconds. The interval lasts the same duration each time it's triggered.
Q. Getting back to comparator A3 in Fig. 1–8, how does this circuit generate a short pulse from the trigger input? In other words, why doesn't the comparator's output hold for as long as I hold the note, like A3 in Fig. 1–4?
A. Fig. 6 explains the function. It might be more accurate to call this comparator a differential comparator, since it reacts to the voltage difference between its inputs, and both voltages are constantly changing. The circuit's input consists of a positive, rectified and smoothed voltage. Between that voltage and each comparator input is a simple lowpass filter—but the filter feeding the inverting (–) input reacts more slowly than the filter feeding the noninverting (+) input. So, whether the input voltage is rising or falling, the voltage at the noninverting input always changes faster. This accounts for the basic action of the circuit. Hysteresis, made directional by D1, reduces sensitivity to ripple in the raw input voltage.
Q. But Fig. 6 describes a comparator with a normally *low* output that flips *high* when triggered. You said that A3 in Fig. 1–8 normally has a *high* output that flips *low* when triggered.
A. Compare Fig. 1–8 with Fig. 6. Diode polarity is reversed, and the 10K and 15K resistors have swapped terminals. These changes explain the inverted function of one circuit versus the other.

If you're interested in other approaches to impulse detection in musical signals, check out Refs. 3–5.
Q. How can I generate a triggered envelope?
A. There are many possible ways. One is to take the output of Fig. 1–4 and isolate the positive pulse by differentiating in Fig. 1–9. This circuit differs from the simple passive differentiator of Fig. 5 in that it isolates the positive pulse; and its output swings only from 1/2V+ to A1's positive limit. That signal fed through Fig. 1–10 yields the corresponding triggered envelope, whose attack and decay vary under control of R8 and R3, respectively, but which don't change from note to note, and don't react to changes in playing dynamics.
Q. Referring to Fig. 1–10, what's the purpose of R4 and R5?
A. The output of Fig. 1–9 is a positive pulse that varies between 1/2V+ and the positive output limit of an 06X op amp. We want the output of the attack/decay circuit to swing from the 06X's negative limit to its positive limit; so we need (1) gain, and (2) some means to alter the resting DC output voltage. Of many possible means to achieve this, we chose to apply the gain and DC offset in the final op amp—A2 in Fig. 1–10.

R4 ties to V+. This causes A2's output to flip to its lower limit in the absence of an opposing input voltage. R5 ties to 1/2V+; this increases the gain of the stage so that the output voltage can swing to A2's positive limit.
Q. Okay, I've got a pretty good handle on the generation of envelope-related control voltages. Now I have questions about individual projects.
A. Fire away.
Q. The first question applies to several projects: What's a "pass-thru"?
A. A pass-thru jack gives you the raw axe output, so you don't need an effect/bypass switch. Say you want to run the raw axe feed into the primary path, and run a processed version of the axe feed into the secondary path. The pass-thru jack lets you do this.
Q. In Attack-O-Matic IV you've used treble emphasis/de-emphasis noise reduction. What's the point of having the de-emphasis take place passively, after the output of an IC?
A. We could have placed the de-emphasis network in the feedback loop of the 570's internal op amp. We chose the outboard approach to reduce noise generated in the 570's internal op amp, as well as hiss from other parts of the signal path.
Q. But the net output impedance then approximates the value of R16, or 10K.
A. That's the same impedance as a typical axe. Amps and most stompboxes have input impedances well over 100K ohms, so no audible loading loss occurs.
Q. Ratchet-O-Matic seems to devote an awful lot of circuitry to achieving a two-state switching function.
A. If that's all it did, yes, it uses a lot of circuitry. But Ratchet-O-Matic takes the circuit in its most basic incarnation. By changing one connection you can make this circuit shift sequentially among any number of outputs, from 2 to 10. Notice, on Ratchet-O-Matic's schematic, that pin-4 of the 4017 ties to pin-15. Pin-15 is the 4017's reset pin. Pin-4 is the third pin in the firing sequence; but by tying pin-4 to pin-15, the chip resets to pin-3, the first pin in the firing sequence. The result is that the high output flips between pin-3 and pin-2. By choosing a later pin in the firing sequence for the reset, the circuit activates any number of outputs between 2 and 10.
Q. What could I build with such a device?
A. Many things; for instance, a ratchet-wah. Fig. 4 gives a detailed example of using the 4017 to create up to 10 different control voltages in sequence. You could also use the circuit to make a multi-input sequential mixer, or a multi-output sequential switcher. You could drive it off an oscillator or a trigger circuit. Use your imagination.
Q. What if I need a control voltage that does things you haven't covered?
A. Such as?
Q. You mentioned delayed intervals and sequential intervals.
A. Check out Fig. 7. This shows the use of 555 timer chips (bipolar or CMOS versions) to realize both functions.
Q. Referring to Fig. 2, what does control with a line over it mean?
A. "Control" and "control with a line over the top" are inverses. Feed the control voltage through a unity-gain inverting amp, and you get its inverse. When control is rising, its inverse is falling, and vice versa.

References

1. Jung, Walter: *IC Timer Cookbook*, 2nd Edition; Howard Sams, 1983, ISBN 0-672-21932-8

2. ——: *IC Op-Amp Cookbook*, 3rd Edition; Howard Sams, 1986, ISBN 0-672-22453-4

3. US Patent No. 6,091,013: Attack Transient Detection for a Musical Instrument Signal

4. US Patent No. 5,710,387: Method for Recognition of the Start of a Note in the Case of Percussion or Plucked Musical Instruments

5. US Patent No. 4,939,471: Impulse Detection Circuit