BUILD THIS PROFESSIONAL DRUM SYNTHESIZER

the DRUM...

A PERCUSSION SYNTHESIZER

For the musician and musician to be. This unique 4-channel synthesizer adds more than just a beat to your music.

STEVE WOOD

PERCUSSION SYNTHESIS SEEMS TO BE growing more popular daily. The trouble is, it's expensive! Or it was. Building The Drum is a good way to get yourself fixed up with a great little percussion synthesizer that can do all the fascinating things that you're hearing on the radio and TV (and much more), without going into the red. The Drum is a four-channel synthesizer consisting of four type-5700 percussion modules.

The Drum has some goodies that don't seem to be available on most percussion synthesizers now on the market. Let's examine the functions of some of the control and interface features on The Drum, and I think you'll see what I mean.

One of the most unique features of The Drum is its sensor device. It's a small audio transducer that can be mounted just about anywhere you want to put it. That means that you don't have to add more "things to hit" to your existing drums. You can simply mount the sensor on one of the drums you are already using and have that drum serve a dual purpose. The Drum synthesizer has provisions for a "cancel" control, such as an ordinary on/off type foot-switch (like the kind used with special-effects for guitar). That way, you don't have to dislocate your arm trying to hit a new piece that's behind you because there was no more room in front or to the sides.

For those who would like something that looks and feels like an actual drum surface, we have found that mounting the sensor in a practice-pad gives good results. However, it has also been noted that the dynamic range (evidenced by differences in synthesizer output pitch and volume level, with respect to the degree of force exerted on the practice-pad or drumhead) is somewhat less when using a practice-pad than that afforded by, say, a tom-tom. The reason is that the tom-tom (and just about any other drum) has a much longer decay time than a practice-pad, and a natural amplification that far exceeds that of the practice-pad. This gives the "envelope follower" circuit in the synthesizer a stronger and longer lasting signal to work with. We'll get into that a little later.

Since there are as many different ways to mount the sensor as one can think of, there must be a control on the synthesizer to allow the drummer to make adjustments for the differences in source-signal amplitude that will be encountered when using various drums and/or practice-pads as the "trigger" source. That control is simply a 500K pot, across which the input signal is dropped. The wiper picks off the desired signal level and feeds it to the input amplifier. We call that control SENSOR GAIN, and it is labeled R1 on the schematic in Fig. 1. The power supply for The Drum is shown in Fig. 2.

turn page for diagrams

Other front-panel controls include: ENVELOPE DECAY TIME, INITIAL PITCH, PITCH MODULATION UP/DOWN (this one is unique; we'll see why shortly), WAVEFORM SELECT/MIX, NOISE/OSCILLATOR MIX, NOISE FILTER (auto sweep or manual), and OUTPUT LEVEL. There are two status-indicator LED's on the front panel, one of them to show when the power is on, and the other to show when a trigger has been sensed.

We will explain the function of all those, as well as the half dozen interface jacks that are associated with The Drum module, in the design analysis.

How it works

The Drum transducer, which converts the mechanical action of striking the drumhead to the electrical input required by the synthesizer board, consists of a piezoelectric element encapsulated in a silicon compound. The silicon encapsulant supports and protects the element as well as serving as a coupling medium for the mechanical excitations. The voltage produced by the transducer is proportional to the magnitude of the mechanical force applied, (how heavily the drumhead is struck.)

The signal that is derived from the transducer is fed to input jack J1 (Fig. 1) and dropped across R1. The wiper of that pot picks off the signal at the desired level and feeds it to the non-inverting amplifier built around IC1-a; in turn, the amplifier

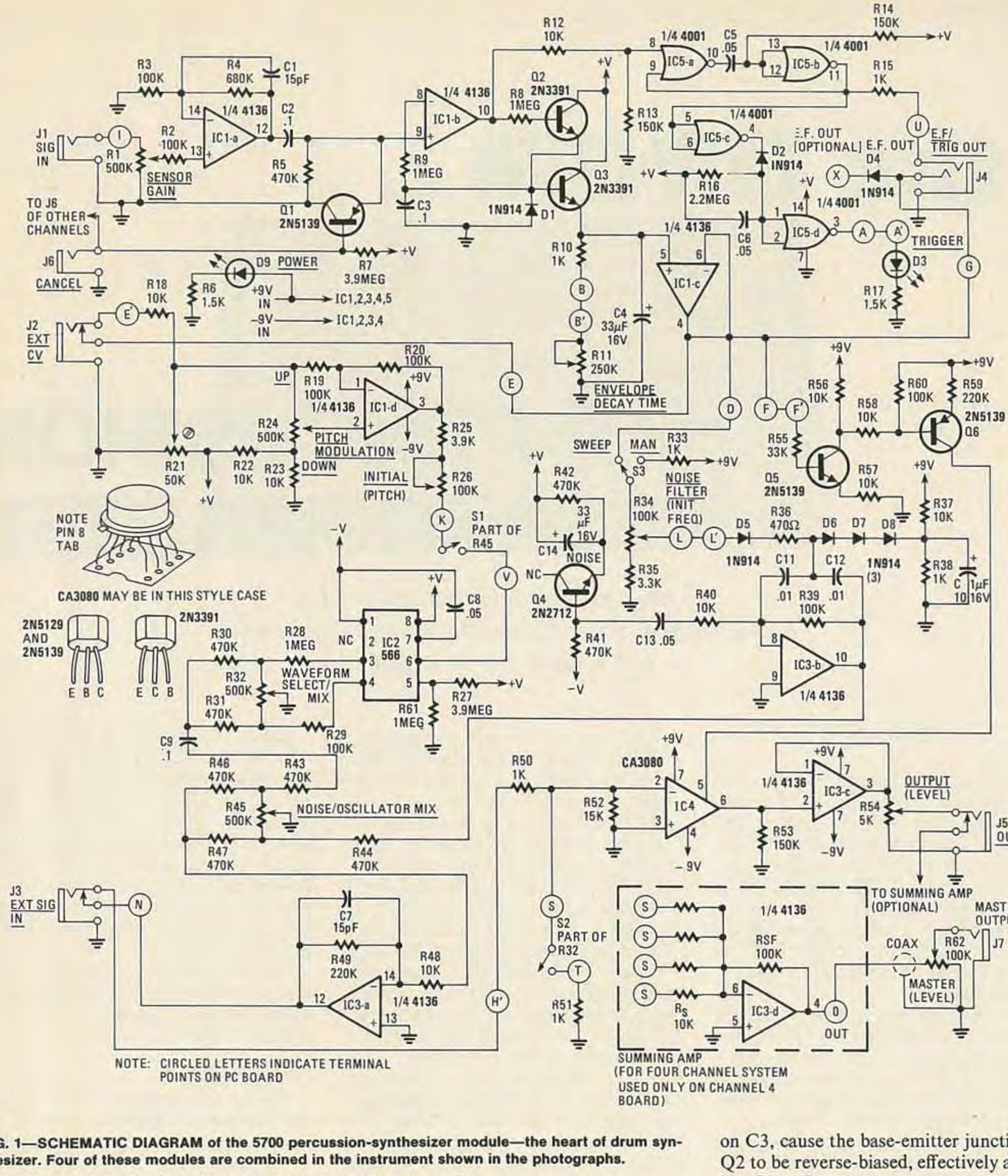

FIG. 1—SCHEMATIC DIAGRAM of the 5700 percussion-synthesizer module—the heart of drum synthesizer. Four of these modules are combined in the instrument shown in the photographs.

is capacitance-coupled to the next stage by C2.

Transistor Q1 allows a contact-closure to ground to serve as a cancelling function. Resistor R7 keeps this transistor's base positive so that it will remain in an off state under normal conditions. By grounding Q1's base through J6, any positive-going transitions of the signal voltage at its emitter will forward-bias it into a conducting state, thereby shunting the signal to ground via Q1's collector. We are not concerned with negative-going portions of the signal as the following stage will simply ignore any voltage going below ground.

The buffered ouput of the transducer is applied to the non-inverting input of opamp stage IC1-b, which, in conjunction with Q2 and associated components, forms an envelope-follower. In response to positive excursions of the input signal, the output of IC1-b goes positive. The emitter of Q2 follows that voltage and charges C3 until its voltage (which is the signal voltage that is applied to IC1-b's inverting input) matches the original signal voltage. Negative input-signal excursions, or in fact an input voltage that is less than the voltage currently appearing on C3, cause the base-emitter junction of Q2 to be reverse-biased, effectively allowing C3 to float.

A second effect of having Q2 reverse-biased is to break IC1-b's feedback loop so that the opamp functions most of the time as a comparator, its output (pin 10) switching between positive and negative supply. When pin 10 switches high, it triggers the monostable one-shot, composed of IC5-a and IC5-b; that produces a single short-duration pulse which is made available at the trigger-output connector of J4. That same short pulse is stretched by the circuitry of IC5-c and IC5-d and used to light the trigger-indicating light-emitting-diode, D3.

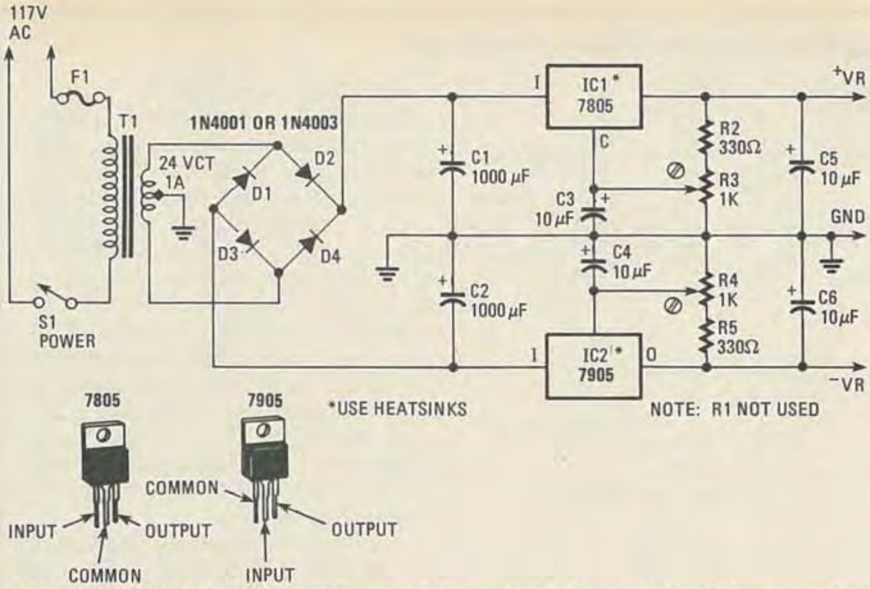

FIG. 2—THE POWER SUPPLY is hefty enough to supply the four modules that are used in the four-channel percussion synthesizer.

PARTS LIST

Resistors ¼ watt, 10% unless otherwise specified
R1, R24—500,000 ohms, potentiometer, linear taper
R2, R3, R19, R20, R29, R39, R60, R_{SF} **(only one needed)**—100,000 ohms
R4—680,000 ohms
R5, R30, R31, R41, R44, R46, R47—470,000 ohms
R6, R17—1500 ohms
R7, R27—3.9 megohms
R8, R9, R28, R61—1 megohm
R10, R15, R33, R38, R50, R51—1000 ohms
R11—250,000 ohms, potentiometer, audio taper
R12, R18, R22, R23, R37, R40, R48, R56, R57, R58, R_S **(only four needed)** 10,000 ohms
R13, R14, R53—150,000 ohms
R16—2.2 megohms
R21—50,000 ohms, trimmer potentiometer
R25—3900 ohms
R26, R34—100,000 ohms, potentiometer, reverse audio taper
R32, R45—500,000 ohms, potentiometer, linear taper with SPST switch
R35—3300 ohms
R36—470 ohms
R49, R59—220,000 ohms
R52—15,000 ohms
R54—5000 ohms, potentiometer, linear taper
R55—33,000 ohms
R62—100,000 ohms, potentiometer, audio taper **(only one needed)**
Capacitors
C1, C7—15 pF, ceramic disc
C2, C3, C9—0.1 μF, Mylar
C4, C14—33 μF, 16 volts or higher, electrolytic
C5, C6, C8, C13—.05 μF ceramic disc
C10—1 μF, 10 volts, electrolytic
C11, C12—.01 μF, polyester
Semiconductors
D1, D2, D5—D8—1N914 or 1N4148
D3, D9—TIL-209-B light-emitting diode
Q1, Q6—2N5139 or PN5129
Q2, Q3—2N3391 (GE)
Q5—2N5129 or PN5129
Q4—2N2712 (GE, Sprague or other, selected for noise output. As supplied in the kit, the center lead has been clipped off.)
IC1, IC3—4136 quad op-amp (Exar, Raytheon, TI)
IC2—566 voltage-controlled oscillator (National, Signetics)
IC4—CA3080 (RCA or equal) operational transconductance amplifier
IC5—CD4001 CMOS quad NOR gate
S1, S2—SPST switch, on R32 and R45, respectively
S3—SPST slide switch
J1, J6, J7—open-circuit phone jack, ¼ inch
J2, J3, J5—closed-circuit phone jack, ¼ inch
J4—stereo phone jack, ¼ inch
Miscellaneous: wire, knobs, hardware, circuit board, front and rear panels, drum transducer, etc.

The following are available from Paia Electronics. Inc., PO Box 14359, Oklahoma City, OK 73114:
No. 5700 —Complete kit of all parts necessary for a single drum module, including drum transducer, circuit board, front panel, etc. $59.95 plus $3.00 postage and handling.
No. 5700PC—Etched, drilled and labeled circuit board for single module. $15.95 postage paid.
No. 5700P—Complete kit for four-module drum set, including case, power supply, and four drum modules. $269.75 plus $10.00 postage and handling.
No. 5700S—Piezoelectric transducer $25.00
No. 4771—Complete kit of parts for power supply $29.95
No. 4771PC—Etched and drilled circuit board for power supply, $6.95
Assembled units available. Write for prices.

POWER SUPPLY PARTS LIST

R1—not used
R2, R5—330 ohms, ½ watt
R3, R4—1000 ohms, trimmer pot
C1, C2—1000 μF, 20 volts, electrolytic
C3-C6—10 μF, 10 volts, electrolytic
D1—D4—1N4001 or 1N4003
IC1—LM340T-5 or 7805 positive voltage regulator, 5 volts
IC2—LM320T-5 or 7905 negative voltage regulator, 5 volts
T1—transformer, 24 volts, CT, 1 amp

Transistor Q3 serves as a second emitter-follower which tracks the voltage on C3 and provides the relatively heavy currents required to charge C4 quickly enough to produce a percussive attack waveform. Capacitor C4's discharge path is through resistor R10 and DECAY control R11. The attack and release (A/R) waveform that appears across C4 is buffered by the voltage-follower IC1-c. IC1-c's output provides the voltage that will control dynamics by means of the voltage-controlled amplifier and sweep the voltage-controlled oscillator and voltage-controlled filter.

Amplifier-stage IC1-d is configured as a sign-changer which allows the A/R control voltage to produce either upscale or downscale pitch shifts from the VCO. After it has been processed by the sign-changer, that control voltage is coupled by R25 and the INITIAL PITCH control R26 to the frequency-control input of the VCO, IC2.

The outputs of the 566 VCO are found at pins 3 (squarewave) and 4 (triangle). Because of the differences in the energy content of a squarewave and a triangle, the squarewave will sound louder. That accounts for the rather large difference between the values of the mixing resistors R28 and R29. The 500K pot R32 serves as a mix control by attenuating the unwanted waveform to the desired degree. Isolation-resistors R30 and R31 sum the mixed signal which is then coupled to the input of the next mixing stage by C9.

Resistor R43 couples the selected or mixed VCO signal to the VCO noise mixer circuit. The other input to this mixer circuit, R44, is fed from IC3-b. IC3-b's output is filtered white noise, generated by Q4—a transistor selected for its noise characteristics when operating in an avalanche condition.

The noise generated by Q4 is picked off at its base and capacitively coupled to the filter/amplifier IC3-b. Diodes D5, D6, D7, D8, and associated components, form the circuitry which sets the corner frequency of that filter. If S3 is switched to make connection with R33, then R34 (INITIAL FREQUENCY) serves as a manual filter frequency control. With S3 switched to sweep (the envelope follower output) the filter will be swept by the envelope-follower output and R34 serves as a sweep-range control.

DRUM SIMULATOR OR PERCUSSION SYNTHESIZER?

JOHN S. SIMONTON, JR.

ELECTRONIC CIRCUITS FOR SIMULATING drum sounds have been around for a long time. In the past they have primarily been simple bridged or parallel T oscillators as shown in Fig. 1. In use, the gain of the amplifier is adjusted so that the circuit is held just below the point of oscillation. When a narrow pulse is applied to one of those oscillators, its normal stability is disturbed and it generates a damped sinusoidal waveform.

That type of circuit is frequently used in automatic percussion units because in that kind of application we are most concerned with the timing of the beats.

The reason that every drummer in the world is not rushing out to replace his bulky and cumbersome instruments with those small, inexpensive electronic equivalents is that devices of that type aren't capable of the dynamic control that a musician needs for personal expression in performance. Damped oscillators are good for simulating the sound of a fixed-pitch drum struck with more or less constant force, but little else.

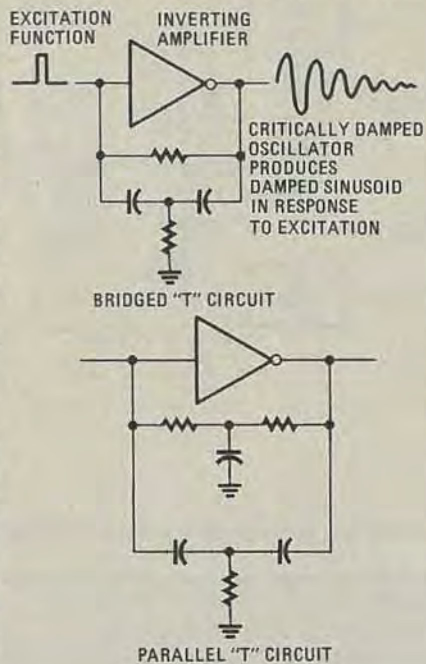

FIG. 1

But recently, many percussionists have begun to use electronics to *supplement* their traditional instruments, using devices that can capture the dynamics and style of their playing. And because the circuitry used in these electronic drums is close kin to that used in modern electronic music synthesizers, drum synthesizers can produce an unbelievably wide range of voices from natural to unearthly.

Figure 2 shows a block diagram of a typical drum synthesizer (The Drum, as it happens). Undoubtedly the most striking difference between that and a more conventional type of music synthesizer is that The Drum has no keyboard, this element's function of real time control being taken over by the drum transducer, a device that translates the force of the stick hitting the drumhead into an electrical signal that the rest of the synthesizer can use.

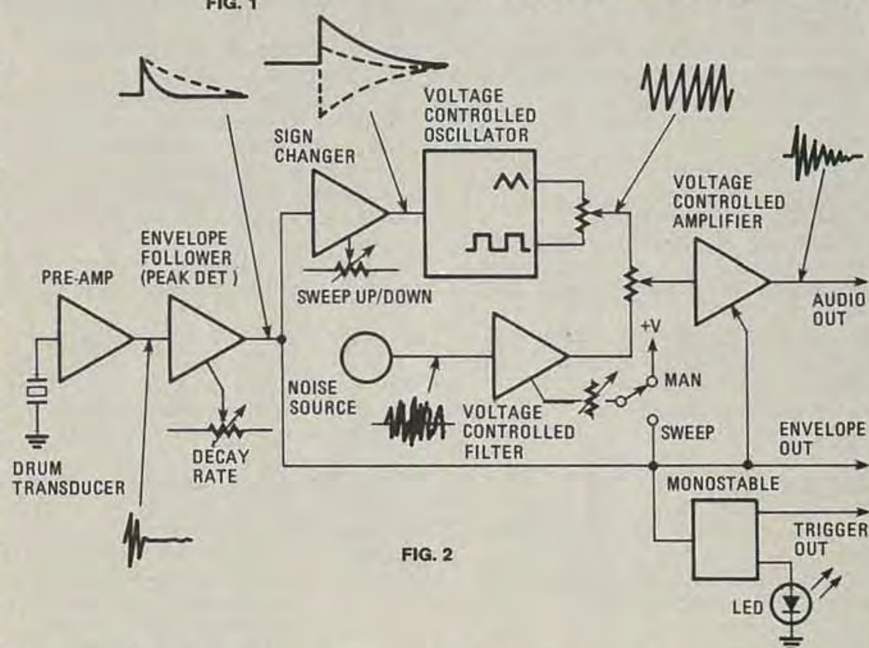

FIG. 2

After being amplified, the output of the transducer is applied to a circuit that is called an envelope follower, but is in fact more a peak detector with a controllable release time. The envelope produced by this circuitry is used in a number of ways. In conjunction with the voltage-controlled amplifier it is used to change the constant amplitude output of an oscillator into the classic percussive sound envelope. That approach is capable of producing longer decay times than are possible with either mechanical drums or damped oscillators. And since the peak output of the envelope follower is related to the output of the drum transducer, which is in turn a function of the striking force, dynamics are preserved.

The control envelope is also applied to a sign changer where it can be either attenuated or inverted depending on the setting of a knob and the resulting new control voltage is used to change the frequency of the primary pitch source, a voltage-controlled oscillator. Because of that the pitch can be modulated either up or down to follow the envelope (like a pedal timpani only with much greater than natural range); or, at mid settings of the control, produce no pitch shift at all.

The use of a VCO as the pitch source also allows us a somewhat broader selection of the tone colors than is allowed by alternative expedients.

In addition to a pitched component, many drums–most notably snares–also have un-pitched components. In the synthesizer, un-pitched sounds are produced by the noise source. Since noise comes in different colors (white, pink, etc.), a voltage-controlled filter is provided to alter the noise spectrum as desired. The filter is voltage controlled so that it too can track the envelope, another effect that can not be duplicated by mechanical drums.

The remaining circuitry (envelope and trigger out, etc.) is useful in combining more than one synthesizer card to produce a single voice.

Resistor R45 works in a manner similar to R32 in the waveform-mix circuit, attenuating either signal to the desired degree. Resistors R46 and R47 sum the mixed signal and feed it to the input of the buffer amplifier IC3-a and from that point the signal is applied to the signal input of the VCA, IC4.

Except when sinewave output is selected, S2 will be closed, putting R51 in parallel with R52. That provides an attenuator at the input of IC4 which will keep the input signal level to the CA3080 transconductance amplifier within its linear operating region (input of 100 mv or less). Opening S2 removes the major portion of the attenuator and allows the VCO triangle output to overdrive the VCA's input slightly, producing a sinewave.

The gain of IC4 is determined by the current that is flowing into pin 5 of the device. That current flow is manipulated by Q5 and Q6 which in turn are controlled by the envelope-follower's A/R output voltage.

We'll discuss construction and use next month. **R-E**