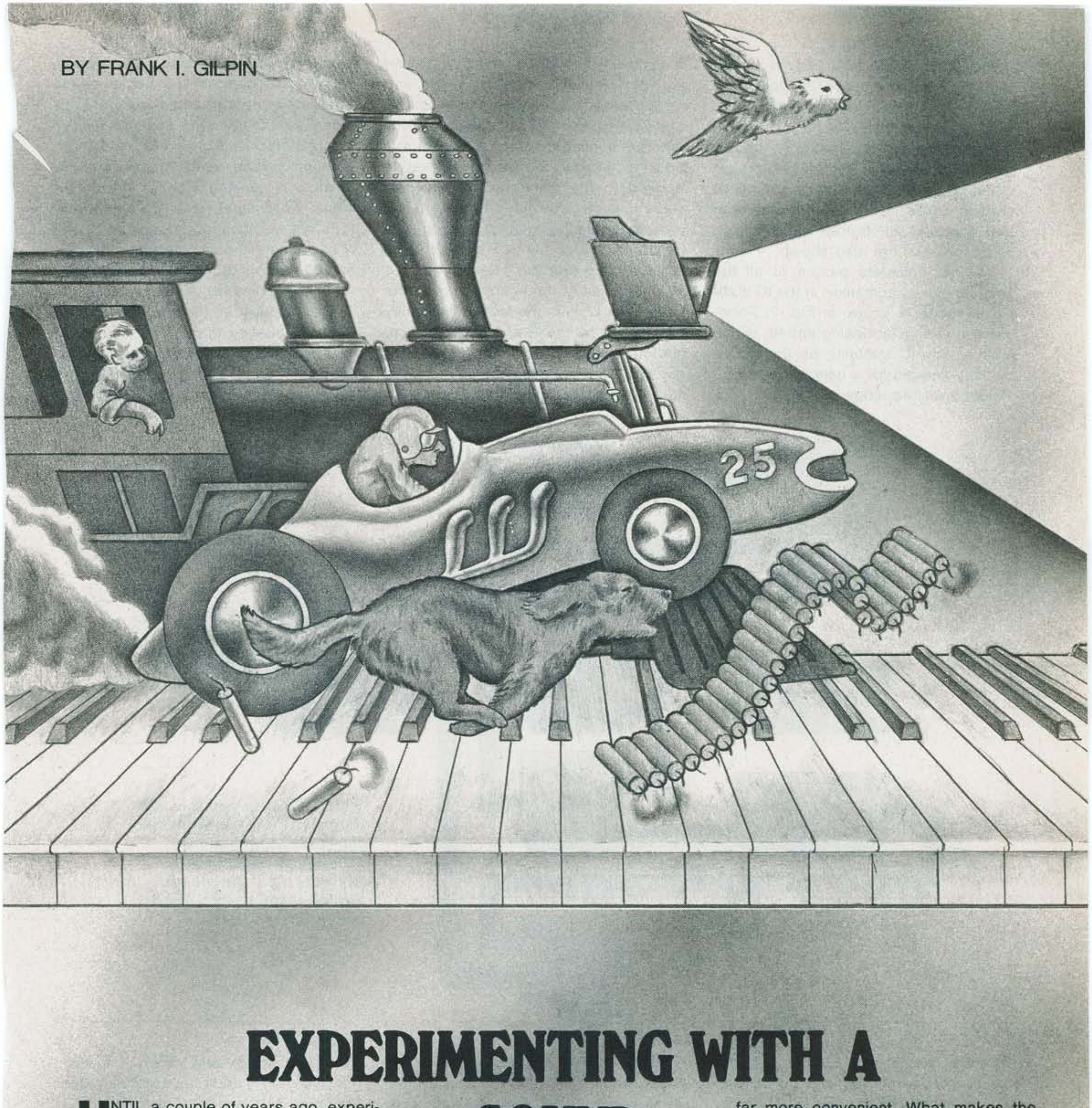
BY FRANK I. GILPIN



EXPERIMENTING WITH A SOUND-EFFECTS GENERATOR

UNTIL a couple of years ago, experimenting with sound-effects circuitry was difficult, requiring a large breadboard to accommodate oscillators of various descriptions, modulators, noise sources, mixers, envelope generators, etc. Now, thanks to Texas Instruments' SN76477 complex sound generator, an integrated circuit that sells nationally for about $3.00, sonic experimentation is far more convenient. What makes the 76477 unique is that it contains all the active circuitry needed to generate just about any sound imaginable. A few resistors and capacitors and a power supply are the only external components required.

Inside the IC Package. By considering its complex circuit as a series of function

With a minimum of extra components and a single Texas Instrument SN76477 IC, you can create a host of different sounds "blocks," it is relatively easy to understand and follow the 76477's operation. In Fig. 1, the IC's function blocks are reduced to simplest form, with basic sound-generating blocks in gray shading and supplemental control blocks in color. Typical waveforms available at various points in the system and what the final output before amplification might look like are also shown.

A more complete picture of all the function blocks contained in the IC's 28-pin package is shown in Fig. 2. Fabricated from bipolar analog and I²L digital blocks, this IC contains all the active circuitry needed for a user to create an almost unlimited range of sounds.

a nominal 0.1-to-30-Hz range, contingent on the values of resistance (*R*) and capacitance (*C*) connected from pins 20 and 21, respectively, to ground. Two outputs are available from this oscillator: a 50% duty-cycle square wave that is applied to the mixer and a triangular wave that can be routed to an external voltage-controlled oscillator (vco) via pin 16 or through the SLF's select logic block to modulate the internal vco.

Modulation of the internal vco covers a 10:1 range, with the lowest frequency determined by the *R* and *C* values connected between pins 18 and 17 to ground. This vco's output goes to the mixer and envelope-select circuits.

signal is present or absent, the system inhibit logic controls the output of the envelope generator and modulator. This signal also toggles the one-shot multivibrator that is used to generate the short-duration pulses used to simulate the sounds of gunshots, bells, and explosions. Time duration of the multivibrator's output signal is determined by the *R* and *C* values connected from pins 24 and 23 to ground. Maximum usable period is approximately 10 seconds.

The output from the one-shot multivibrator is passed through the envelope-select circuit that determines envelope shape and is used to modulate the envelope generator and modulator.

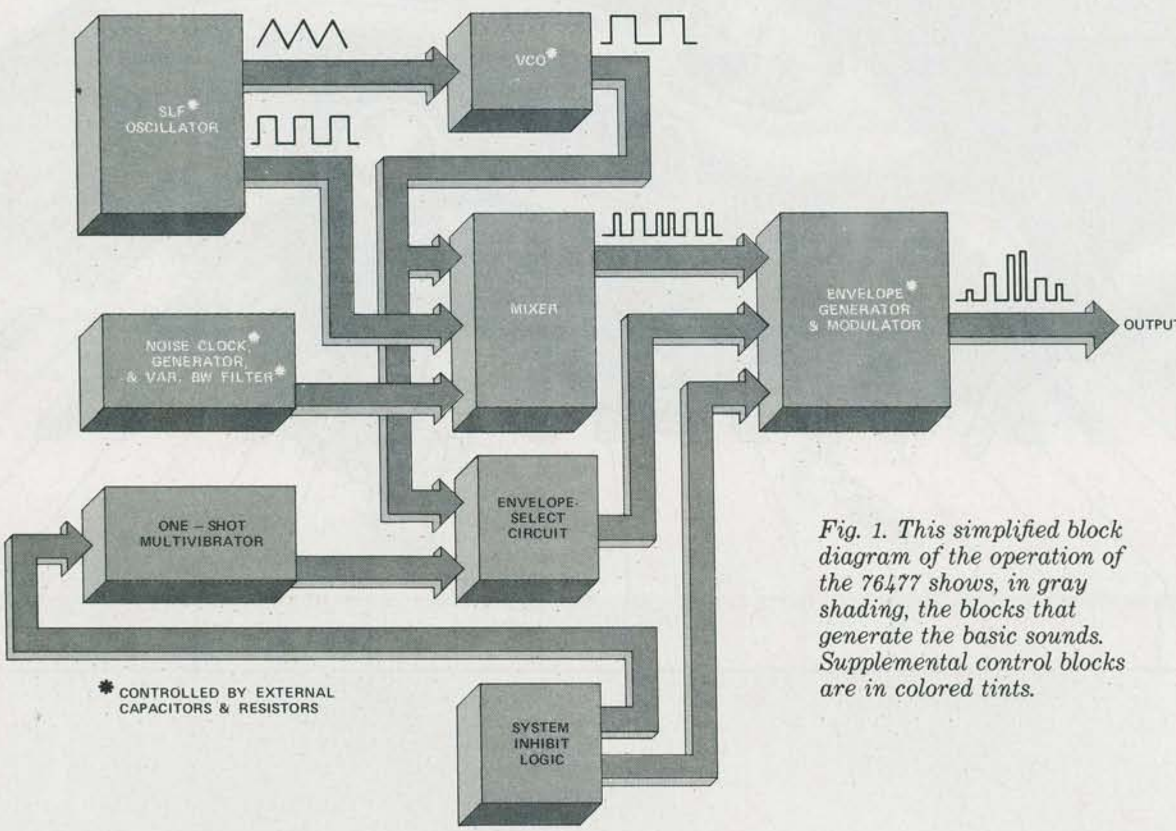


Fig. 1. This simplified block diagram of the operation of the 76477 shows, in gray shading, the blocks that generate the basic sounds. Supplemental control blocks are in colored tints.

Desired sounds are all user defined. You simply switch into and out of the IC's circuit resistor and capacitor values and set a few logic states to "tailor" the audio parameter you require. Sounds of gunshots, explosions, sirens, musical instruments, "phaser" guns, etc., can be simulated. You can even create sounds you never heard before.

An audio amplifier is built into the IC, but you can route its output to a high-quality audio amplifier to obtain a louder, richer sound.

Chip Operation. The super-low-frequency (SLF) oscillator in the 76477 has

Output pulses from the noise clock, whose frequency is determined by the resistance values connected from pins 3 and 4 to ground, are used to control the noise generator. The output from the noise generator is passed through a variable-bandwidth noise filter, controlled by the *R* and *C* values from pins 5 and 6 to ground, to the mixer.

The mixer combines the three inputs (from the noise filter, the SLF's square-wave generator, and the vco) and, contingent on the dc states of its three selector inputs, at pins 25, 26, and 27, determines type of mixer-output signal.

Depending on whether a 5-volt control

Modulator attack and decay are controlled by the *R* and *C* values connected from pins 7, 8, and 10 to ground.

The final signal is applied to the audio amplifier, which develops a 2.5-volt peak-to-peak maximum low-impedance output at pin 13. A feedback resistor can be connected between pins 12 and 13 to modify the amplifier's gain.

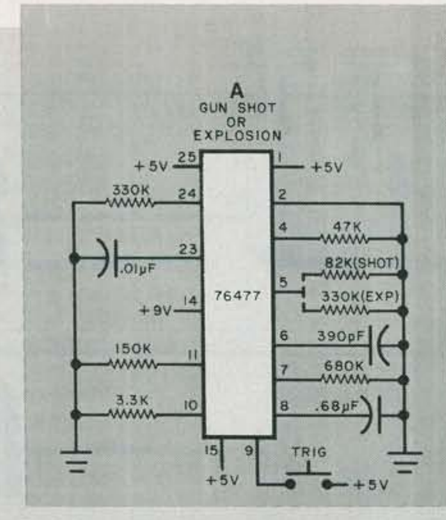
There are 23 variables under user control with the 76477 sound generator. Hence, you can be kept occupied for a considerable time exploring the effects that can be obtained with various combinations of controls.

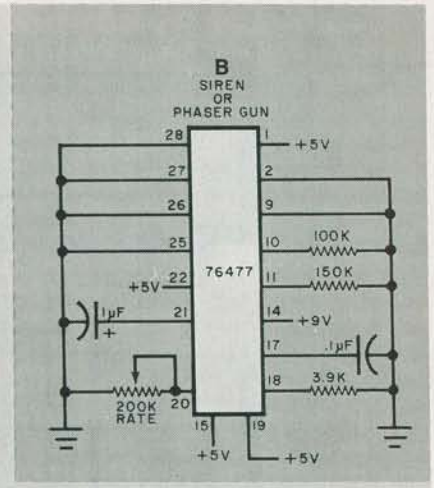
(continued on next page)

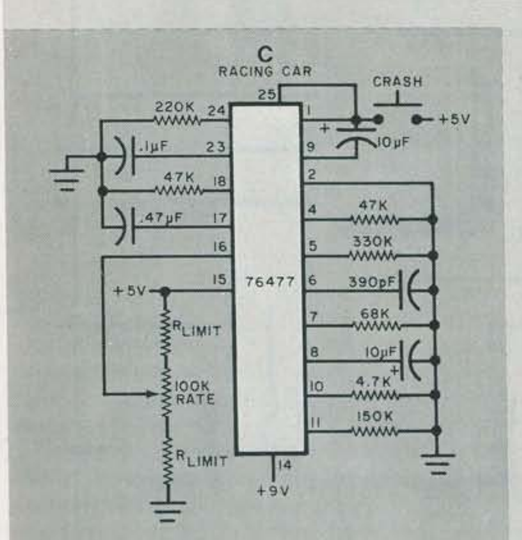
Fun Circuits You Can Build

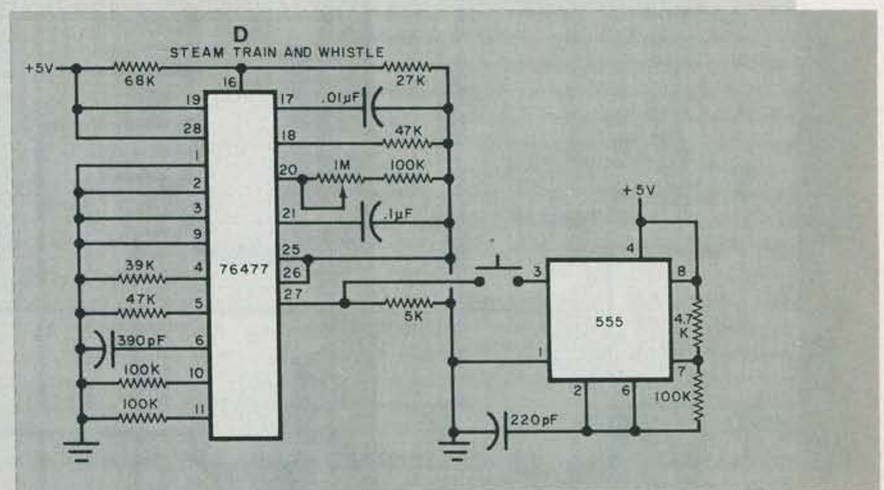
In this section, we present five fun circuits that typify some of the uses to which the SN76477 complex sound generator IC can be put. All are relatively simple and inexpensive to build, because the IC contains all the active circuitry needed.

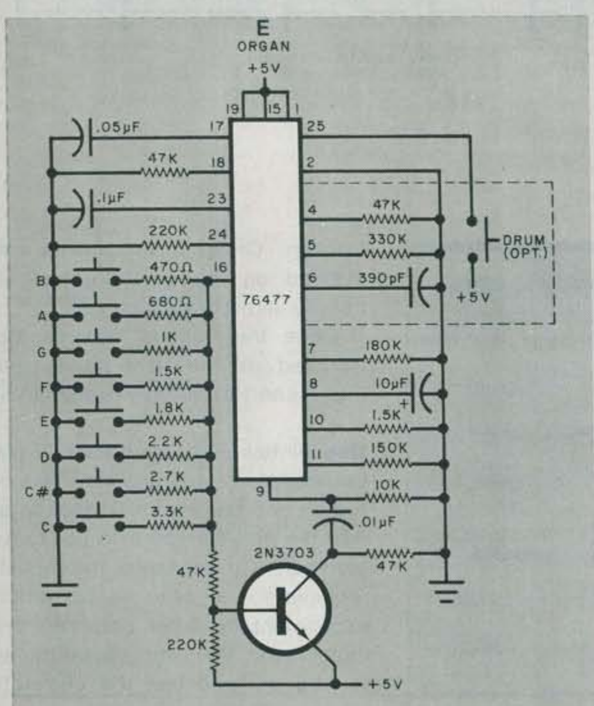
Circuits A, B, and C can be used to add realistic sound effects to the animation in video games. The model railroader will find circuit D useful, while the electronic "organ" in circuit E should appeal to all, especially children. Finally, circuit F illustrates how an outboard transistor amplifier stage can be added to increase the power delivered to the speaker.

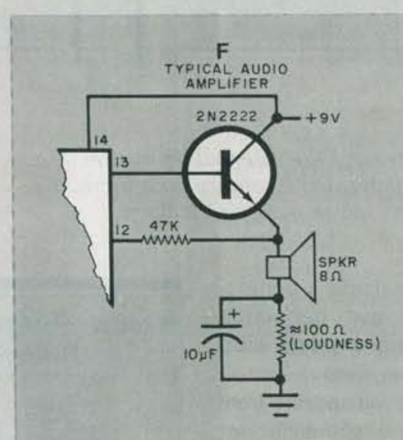












Practical Breadboard. Shown in Fig. 3 is the circuit of a practical experimenter's "breadboard." Although the circuit is really quite simple, to utilize the full capabilities of the 76477 sound generator, a rather large cabinet is required to accommodate all the switches and jacks shown.

You can use a small piece of perforated board on which to mount *IC1* (a socket is recommended) and the *Q1*/*Q2* audio amplifier circuit. Alternatively,

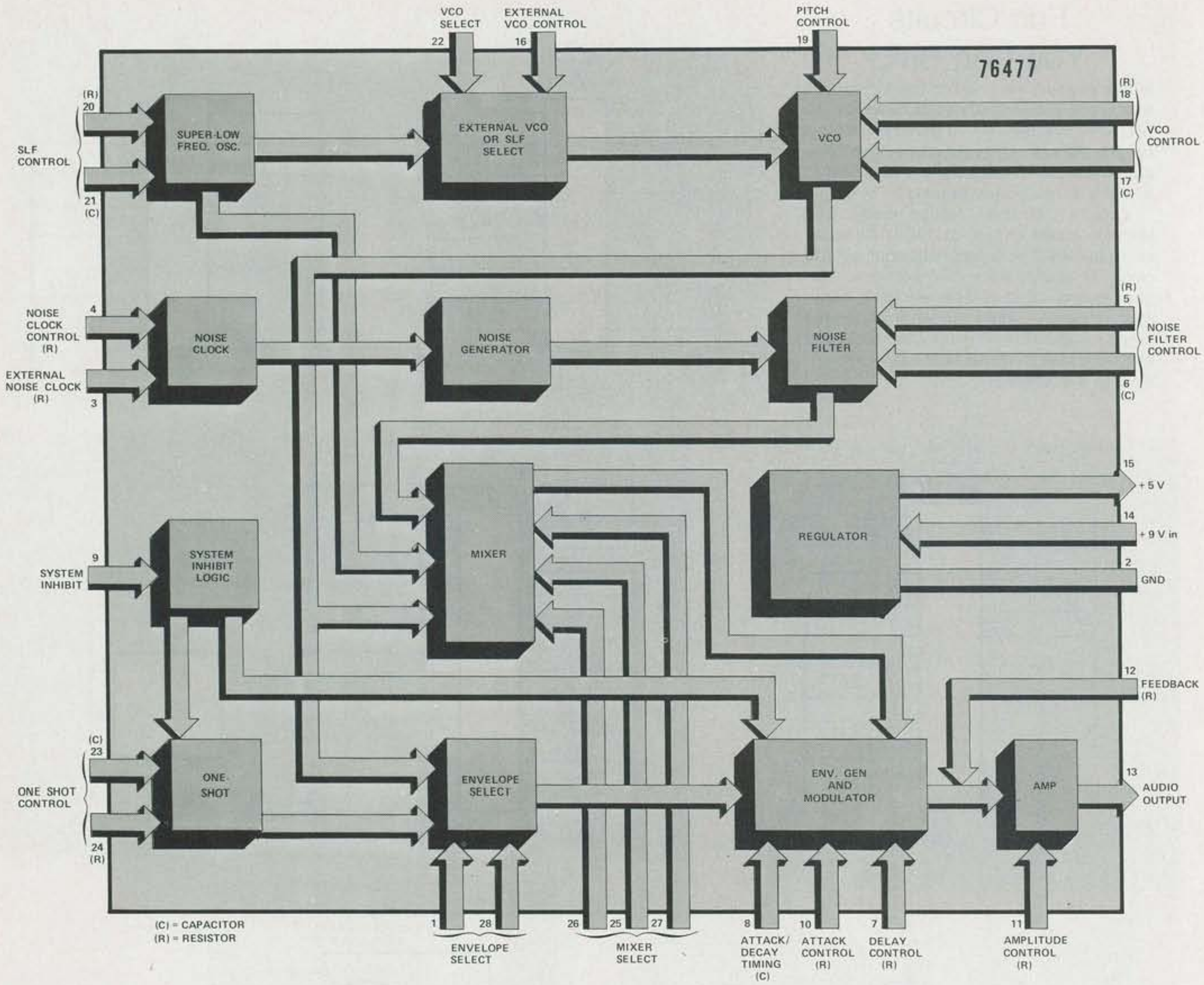


Fig. 2. The block diagram of the internal operation of a 76477 complex sound generator IC shows how it contains a complete sound-effects lab in a 28-pin package.

you can design and fabricate a printed-circuit board. If you use perforated board, you can Wire Wrap or pencil wrap the components into the circuit.

Although the system will operate from a standard 9-volt battery, you might opt for a small power supply that can deliver 7.5 to 9 volts instead, if only to free yourself from having to replace batteries periodically. Make sure, however, that the cabinet you select will accommodate all controls, jacks, and circuitry.

All 28 switches, 12 banana or tip jacks, and 8 potentiometers should be mounted on the front "control" panel and suitably identified with a dry-transfer lettering kit. To simplify experimenting, switches, jacks, and pots should be identified according to function as shown in Tables I through III. Table IV is an example of grouping according to function. Group arrangements can be outlined on the control panel with a heavily inked or painted line.

TABLE I—JACK IDENTIFICATION

J1	Input for external noise oscillator
J2	Input for external voltage-controlled oscillator
J3	Noise filter resistance measurement jack with *R4*
J4	Decay resistance measurement jack with *R6*
J5	Attack resistance measurement jack with *R8*
J6	Audio output
J7	External vco measurement jack with *R15*
J8	Vco control resistance measurement jack with *R18*
J9	Pitch control resistance measurement jack with *R23*
J10	SLF oscillator control resistance measurement jack with *R25*
J11	One-shot resistance measurement jack with *R27*
J12	Common ground

Once the various components are mounted on the front panel, refer to Fig. 3 and wire them into the circuit.

Use. Note in Fig. 3 that each IC pin that terminates in a potentiometer has both a switch and banana or tip jack in series with the pot. This permits you to use an ohmmeter to measure the resistance required for a given sound, arrived at experimentally. After obtaining the desired sound, you simply open the switch for the pot and use the ohmmeter to measure the resistance from the associated jack to ground. If you keep a log of the various resistances and capacitances required for particular sounds, they can be duplicated on demand.

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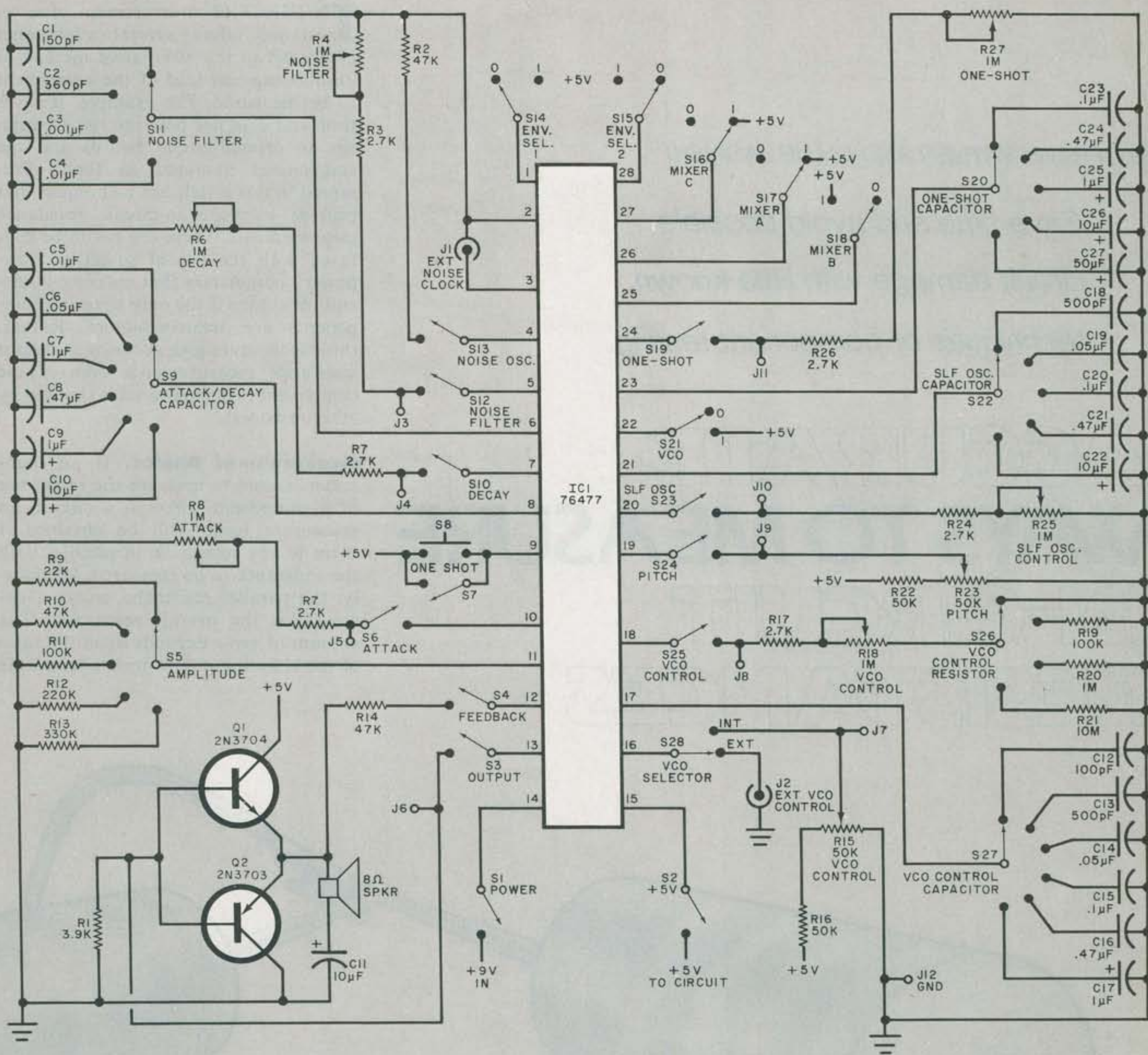

Fig. 3. The circuit for a complete sound-effects generator uses 28 switches, 12 banana (or tip) jacks and eight potentiometers to allow a broad selection of controllable parameters.

PARTS LIST

B1—9-volt battery (see text)
C1—150-pF capacitor
C2—360-pF capacitor
C3—0.001-µF capacitor
C4,C5—0.01-µF capacitor
C6,C14,C19—0.05-µF capacitor
C7,C15,C20,C23—0.1-µF capacitor
C8,C16,C21,C24—0.47-µF capacitor
C9,C17,C25—1-µF capacitor
C10,C11,C22,C26—10-µF, 15-volt electrolytic
C12—100-pF capacitor
C13,C18—500-pF capacitor
C27—50-µF, 15-volt electrolytic
IC1—SN76477N complex sound generator (Radio Shack 276-1765 or similar)
J1,J2—RCA phono jacks
J3 through J12—pin or banana jacks
Q1—2N3703 transistor
Q2—2N3704 transistor
The following are ½-watt, 10% resistors unless otherwise noted:
R1—3900 ohms
R2,R10,R14—47,000 ohms
R3,R5,R7,R17,R24,R26—2700 ohms
R4,R6,R8,R18,R25,R27—1-megohm linear-taper potentiometer
R9—22,000 ohms
R11,R19—100,000 ohms
R12—220,000 ohms
R13—330,000 ohms
R15,R23—50,000-ohm linear-taper potentiometer
R16,R22—50,000 ohms
R20—1 megohm
R21—10 megohms
S1 through S4,S6,S7,S10,S12 through S19,S21,S23 through S25—Spst slide or toggle switch
S5,S20,S22—Single-pole, 5-position nonshorting rotary switch
S8—Normally open, momentary-contact pushbutton switch
S9,S27—Single-pole, 5-position nonshorting rotary switch
S11,S26—Single-pole, 4-position nonshorting rotary switch
S28—Spdt slide or toggle switch
Misc.—Battery holder; 28-pin DIP socket for IC1; dry-transfer lettering kit; suitable enclosure; control knobs and dial plates (7); etc.

Sound Effects *(continued from page 42)*

Since the circuit can generate a very wide variety of sounds, let us give an example of how you might go about "tailoring" a specific sound with the bread-

TABLE II—SWITCH IDENTIFICATION

S1	Power switch for 7.5-to-9-volt dc supply
S2	Power switch for 5-volt dc supply
S3	Output
S4	Feedback
S5	Amplitude resistance selector
S6	Attack resistance
S7	One-shot, constant when closed
S8	One-shot momentary
S9	Attack-decay timing capacitor selector
S10	Decay resistance
S11	Noise filter capacitor selector
S12	Noise filter resistance
S13	Noise oscillator resistor
S14	Envelope select 1: logic 0, logic 1
S15	Envelope select 2: logic 0, logic 1
S16	Mixer C: logic 0, logic 1
S17	Mixer A: logic 0, logic 1
S18	Mixer B: logic 0, logic 1
S19	One-shot resistance
S20	One-shot capacitor selector
S21	Voltage-controlled oscillator (vco): logic 0, logic 1
S22	SLF oscillator control capacitor selector
S23	SLF oscillator control resistance
S24	Pitch control resistance
S25	Vco control resistance
S26	Vco control resistance selector
S27	Vco control capacitor selector
S28	Internal/external vco selector

TABLE III—CONTROL IDENTIFICATION

R4	Noise filter control
R6	Decay control
R8	Attack control
R15	Vco control
R18	Vco control
R23	Pitch control
R25	SLF control
R27	One-shot multivibrator control

TABLE IV—CONTROL GROUPING

One-Shot	J11,R27,S7,S8,S19,S20
Noise Filter	J3,R4,S11,S12
VCO Control	J7,J8,J9,R15,R18,R23,S21, S24,S25,S26,S27,S28
SLF Control	J10,R25,S22,S23
Noise Clock	S13
Mixer Select	S16,S17,S18
Envelope	J4,J5,R6,R8,S6,S9,S10, S14,S15
Amplitude	S5
Audio Output	J6,S3,S4
Power On/Off	S1
+5 volts	S2
Ground	J12

board. In this example, we will use the sound of a gunshot.

First, close FEEDBACK switch *S3* and OUTPUT switch *S4* to place the audio amplifier in the circuit. Then close +5V switch *S2* to activate the +5-volt line. Main POWER switch *S1* can now be closed when you are ready to experiment with the controls.

Since a gunshot has fast attack and relatively brief decay times, close ATTACK and DECAY switches *S6* and *S10*, respectively, to permit you to adjust attack and decay times via ATTACK and DECAY pots *R8* and *R6*. As you experiment with various settings of these controls, close main POWER switch *S1* and press and release ONE SHOT switch *S8* to hear the gunshot sound for each combination of settings. Adjust *R6* and *R8* and press and release *S8* until the sound obtained is "just right." (Calibrated index scales behind each potentiometer control knob will simplify recording of settings.)

If desired, required values of attack and decay time resistances can be measured and recorded by opening the ATTACK and DECAY switches and measuring with an ohmmeter between DECAY jack *J4* and ground and between ATTACK jack *J5* and ground. ENVELOPE SELECT 1 and 2 switches *S14* and *S15* can also be preset for the required envelope.

To produce an explosion instead of a gunshot sound, close NOISE FILTER switch *S12* and adjust NOISE FILTER control *R4* for the desired effect.

In Conclusion. The sound-effects generator breadboard presented here can be used in either or both of two ways. For the designer, it is a "tool" that simplifies designing a circuit from scratch. One can "design" a circuit with the breadboard, measure resistances of the controls and read off capacitor and logic-state (+5V or 0) settings from the panel, and assemble the circuit around a separate 76477 generator chip. The other way to use the breadboard is to simply experiment with control and switch setting combinations until you hear a sound you like. Used in this manner, you can record a whole series of sound effects that can be used with home movies and slide shows, for theatrical events, etc.

Whichever way you use the breadboard, it is a good idea to log parameter values for given sounds for future reference. Then, any time you want to reproduce a sound arrived at experimentally, you can, simply by setting the controls and switches as detailed in your log. ◇