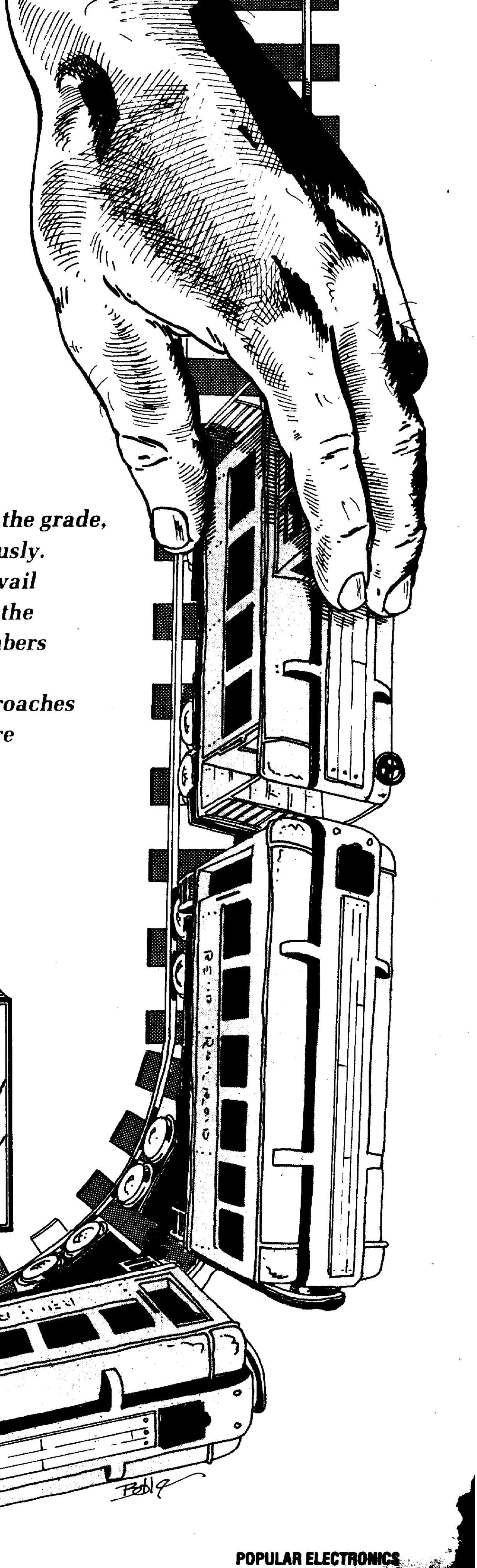
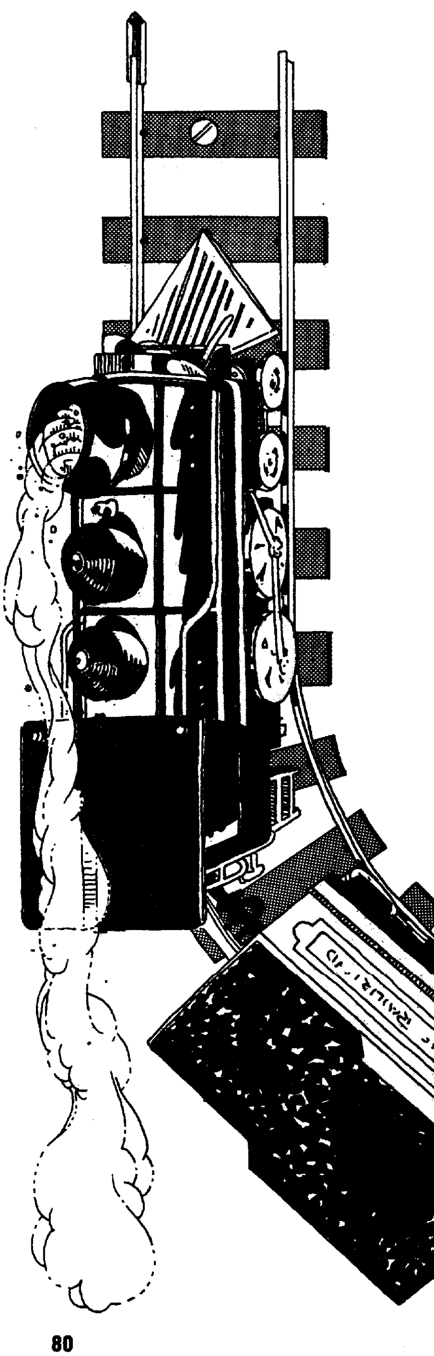
MODEL RAILROAD SOUND SYNTHESIZER

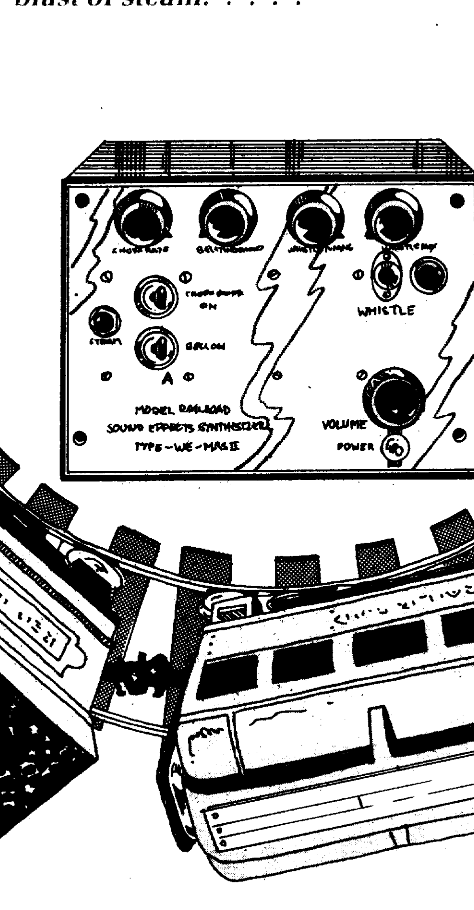
BY HAROLD WRIGHT

ADD CONTROLLABLE "CHUFF-CHUFF", STEAM, WHISTLE, AND BELL SOUNDS TO YOUR MODEL RAILROAD LAYOUT AT LOW COST



The train comes roaring down the grade, steam "chuff-chuffing" furiously. As it nears a grade crossing, the wail of the steam whistle is heard and the crossing bars drop. The train lumbers through the crossing and starts laboring on an upgrade as it approaches the station, its bell clanging. There is a full head of steam on, and as the train comes to a halt, a safety valve lets go with a thunderous blast of steam. . . . .





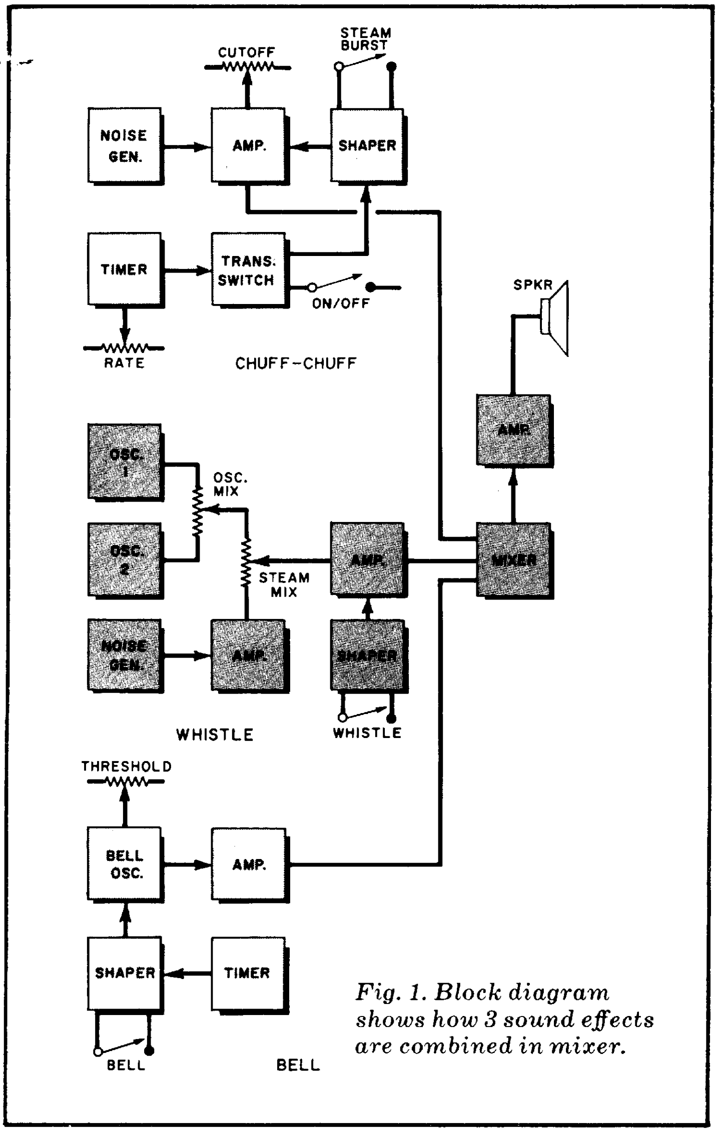


Fig. 1. Block diagram shows how 3 sound effects are combined in mixer.

All of the sound effects described on the preceding page can be obtained in your model train layout if you build this sound synthesizer. Using relatively simple circuits and readily available components, the system can be assembled easily in a few hours. The loudness of the sounds obtained is determined by the audio amplifier that you use in conjunction with the synthesizer.

Since most modern railroad layouts are already equipped with electrically operated switches, signal lights, and speed controls, the addition of the sound synthesizer will have the effect of turning your system from a silent movie into one with sound. The synthesized sounds are quite realistic and are of a wide variety. They can range from those of a distant, rapidly approaching train, with the volume increasing as the train approaches and slows down for the station, to the noise of wheels slipping on an engine trying to start with too large a load.

A block diagram of the complete synthesizer is shown in Fig. 1. It consists of four more-or-less independent circuits: a "chuff-chuff" generator for the steam sound, a whistle generator, a bell circuit, and a three-channel signal mixer.

Chuff-Chuff. As shown in Fig. 2, transistor *Q1* is operated in the avalanche mode and generates a steady white noise (hiss) signal across *R2*. This signal is applied to amplifier *Q3*, which is adjusted to a point just below cutoff by *R10*.

Timer *IC1* produces pulses at a rate

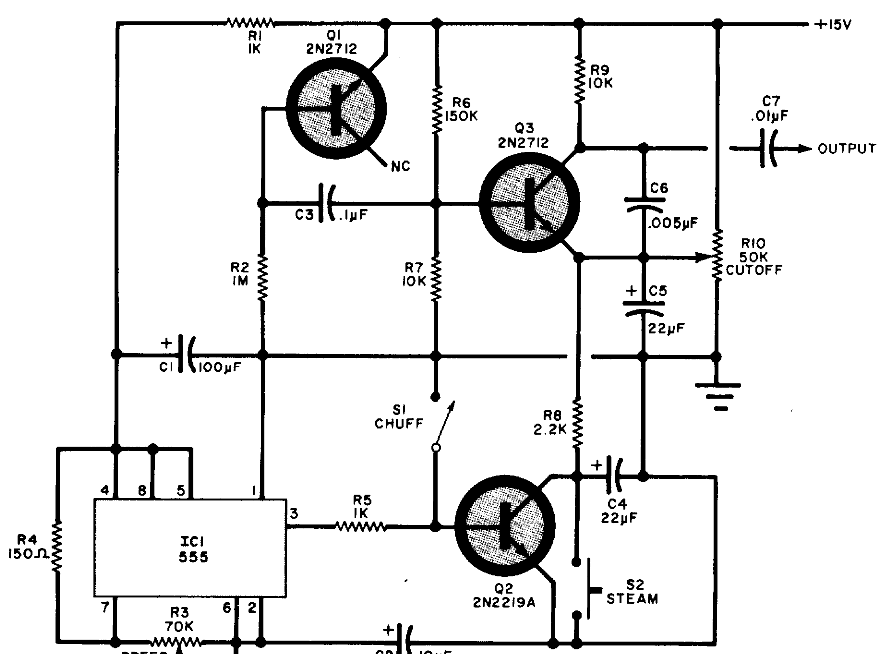


Fig. 2. Steam sound comes from white-noise generator Q1.

PARTS LIST
CHUFF-CHUFF

C1—100-μF, 25-V electrolytic capacitor
C2—10-μF, 25-V electrolytic capacitor
C3—0.1-μF capacitor
C4,C5—22-μF, 25-V electrolytic capacitor
C6—0.005-μF capacitor
C7—0.01-μF capacitor
IC1—555 timer
Q1,Q3—2N2712 transistor
Q2—2N2219 transistor
The following resistors are ½-W carbon composition unless otherwise noted:
R1,R5—1000 ohms
R2—1 megohm
R3—70,000-ohm panel-mount potentiometer
R4—150 ohms
R6—150,000 ohms
R7,R9—10,000 ohms
R8—2200 ohms
R10—50,000-ohm board-mount potentiometer
S1—Spst switch
S2—Spst NO pushbutton switch

determined by *C2* and the setting of *R3*. Thus, *R3* is the chuff-chuff speed control and, with the values shown, can be set to provide sounds from those of a slow starting engine to very fast bursts of steam. Make sure that *R4* is not less than 150 ohms or the speed setting will be unstable.

The pulses from *IC1* are applied to *Q2*, which functions as an electronic switch. When *Q2* conducts, *R8* is shunted across the lower portion of *R10*, thus bringing *Q3* above cutoff. Transistor *Q3* then amplifies for one chuff. Capacitor *C6* rolls off some of the high frequencies to produce a softer steam sound. Capacitors *C4* and *C5* shape the starting and stopping of the individual chuffs. The +15-volt supply is decoupled by *R1/C1* to keep any pulses from getting into the remainder of the circuit.

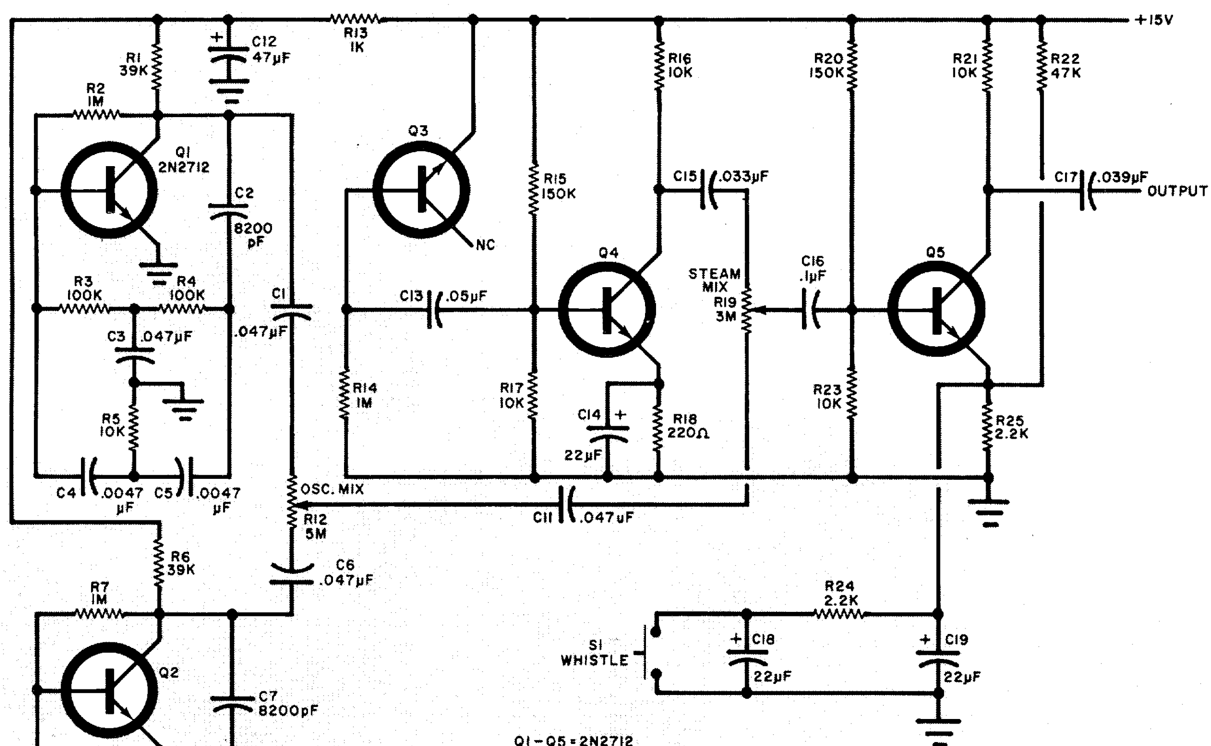
Whistle. In this circuit, shown in Fig. 3, transistor *Q1* is a fixed tuned twin-T oscillator. The circuit for *Q2* is almost identical except for tuning control *R11*. The second oscillator can be tuned from a zero-beat with the first oscillator to a frequency that simulates the two-tone effect similar to that heard from a diesel engine. Points between can be selected for a variety of sounds, including a steam whistle.

Because the outputs of the two oscillators are fed to potentiometer *R12*, a further range of possible tones exists. The power supply to the oscillators is decoupled by *R13* and *C12*.

Transistor *Q3* is connected as an avalanche-mode white-noise source, whose output (across *R14*) is amplified by *Q4*. The output of *Q4* is fed to potentiometer *R19* along with the output of the two tone oscillators. The final mix of tone and steam is fed to amplifier *Q5*.

When whistle pushbutton *S1* is open, resistors *R22* and *R25* keep the emitter of *Q5* at a higher potential than the base, so that the transistor is cut off. When *S1* is closed, *R24* is grounded, shunting it across *R25*. This causes *C19* to reach a lower charge level since it is now being discharged by *R24*. Thus the start of each whistle is made less abrupt to simulate a real steam whistle. When *S1* is released, the recharging of *C18* removes the terminal thump.

Bell. In the circuit in Fig. 4, transistor *Q1* operates as a twin-T oscillator with potentiometer *R7* set so that the circuit is just below the point of oscillation. If this control is set too low, the bell sound will be dull and have too short a decay time. Transistor *Q2* is an emitter follower isolator between the bell oscillator and the mixer stage. Timer *IC1* generates pulses to produce repetitive ringing with the rate (about one per second) determined by *R15* and *C9*. The value of *R15* can be reduced to increase the ringing rate of the bell.



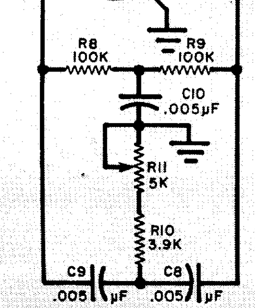
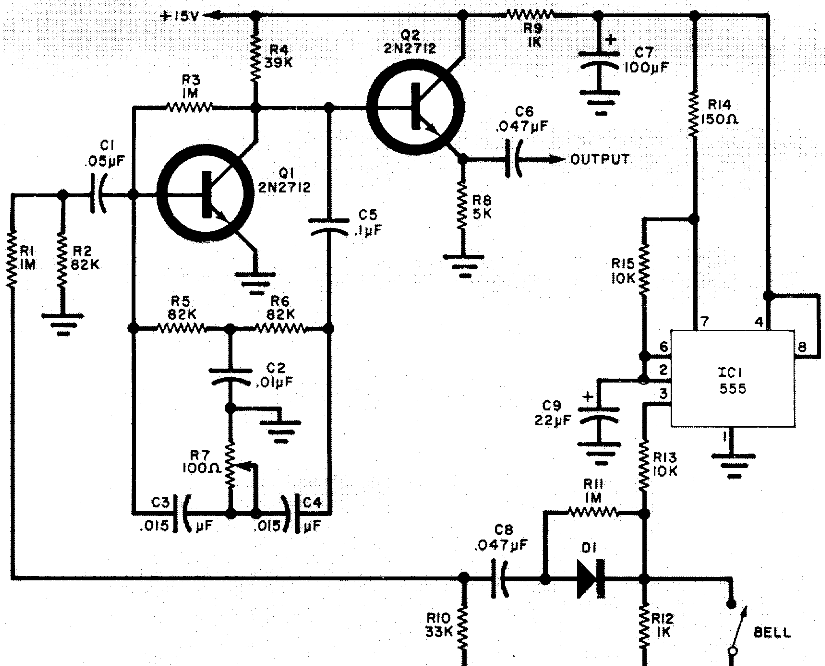


Fig. 3. Oscillator Q1 and Q2 take white noise from Q3 to create steam plus whistle.

PARTS LIST WHISTLE

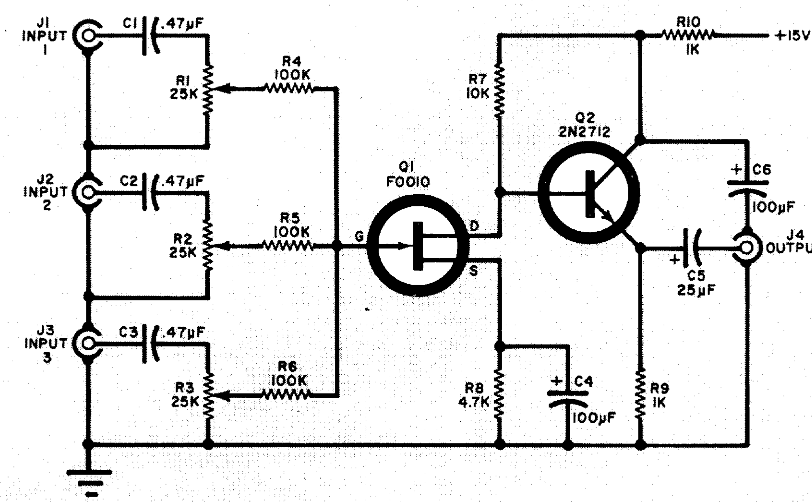
C1,C3,C6,C11—0.047-µF capacitor
C2,C7—8200-pF capacitor
C4,C5—0.0047-µF capacitor
C8,C9,C10—0.005-µF capacitor
C12—47-µF, 25-V electrolytic capacitor
C13—0.05-µF capacitor
C14,C18,C19—22-µF, 25-V electrolytic capacitor
C15—0.033-µF capacitor
C16—0.1-µF capacitor
C17—0.039-µF capacitor
Q1 through Q5—2N2712 transistor
The following resistors are ½-W carbon composition unless otherwise noted:
R1,R6—39,000 ohms
R2,R7,R14—1 megohm
R3,R4,R8,R9—100,000 ohms
R5,R16,R17,R21,R23—10,000 ohms
R10—3900 ohms
R11—5000-ohm panel-mount potentiometer
R12—5-megohm panel-mount potentiometer
R13—1000 ohms
R15,R20—150,000 ohms
R18—220 ohms
R19—3-megohm board-mount potentiometer
R22—47,000 ohms
R24,R25—2200 ohms
S1—Spst NO pushbutton switch



PARTS LIST
BELL

C1—0.05-µF capacitor
C2—0.01-µF capacitor
C3,C4—0.015-µF capacitor
C5—0.1-µF capacitor
C6,C8—0.047-µF capacitor
C7—100-µF, 25-V electrolytic capacitor
C9—22-µF, 25-V electrolytic capacitor
D1—Silicon diode rectifier
IC1—555 timer
Q1,Q2—2N2712 transistor
The following resistors are ½-W carbon composition unless otherwise noted:
R1,R3,R11—1 megohm
R2,R5,R6—82,000 ohms
R4—39,000 ohms
R7—100-ohm panel-mount potentiometer
R8—5000 ohms
R9,R12—1000 ohms
R10—33,000 ohms
R13,R15—10,000 ohms
R14—150 ohms
S1—Spst switch

Fig. 4. Bell circuit uses twin-T oscillator Q1 and switch.



PARTS LIST
MIXER

C1,C2,C3—0.47-µF capacitor
C4,C6—100-µF, 25-V electrolytic capacitor
C5—25-µF, 25-V electrolytic capacitor
J1 through J4—Phono connectors
Q1—HEPF0010 FET
Q2—2N2712 transistor
The following resistors are ½-W carbon composition unless otherwise noted:
R1,R2,R3—25,000-ohm board-mount potentiometer
R4,R5,R6—100,000 ohms
R7—10,000 ohms
R8—4700 ohms
R9,R10—1000 ohms
Misc.—Board, wire, solder, etc. for all four circuits.

Fig. 5. Sound effects are combined in Q1 and drive amplifier through Q2.

The output of *IC1* (pin 3) is applied to the voltage divider made up of *R13* and *R12* to reduce the signal level. The pulses are then rectified by *D1* and differentiated by *C8* and *R10* to produce sharp spikes that trigger the twin-T oscillator, *Q1*.

Mixer. The outputs of the three sound-effect circuits are combined in the circuit shown in Fig. 5. Each input is coupled to its own level potentiometer (*R1, R2,* or *R3*) and they are combined at the gate of FET *Q1*. The output of *Q1* is coupled to the external audio amplifier through emitter follower *Q2* and capacitor *C6*.

Construction. The easiest approach to construction of the synthesizer is to build each circuit on its own small board. You can use perforated board and point-to-point wiring or make a small pc board. The arrangement is not critical. Each board can be built and tested using a 15-volt supply and an earphone (or a small amplifier/speaker combination). Be sure that transients generated by the timer IC's are not coupled into any of the circuits. If necessary, more +15-volt line decoupling is recommended. Sockets can be used for the transistors and IC's.

In the prototype, short lengths of shielded audio cable were used to couple the output of the three sound-effect circuits to the mixer inputs. Another length of shielded audio cable connected the mixer output to the audio system being used.

The boards can be installed in any type of chassis, with all controls on the front panel, clearly identified.

Use. Connect the mixer output to a good-quality audio amplifier and speaker combination. In the bell circuit, set the threshold potentiometer (*R7*) for the best sound when bell switch *S1* is operated. There should be no clicks or pops. Do not try to control circuits by turning the power on and off.

The chuff-chuff has three front-panel controls with *R3* being the rate control, *S2* providing steam bursts, and *S1* for on-off. It is best to group these three controls together so that they can be operated with the fingers of one hand. The whistle circuit has one switch (*S1*); the three internal potentiometers in this circuit should be preset.

If your train system is already equipped with electronic speed controls, you might consider ganging the chuff-rate potentiometer with the train speed control potentiometer for smoother operation of the complete system. ◇