Road Runner

Sound effects from outer space to put in your car, desk, brief case......

ODDLY ENOUGH, most electronic hobbyists are unable to produce odd electronic sounds on demand. Anybody can produce an oscillator or a gated multivibrator, but what about sirens, horns or those 'weird space type' sounds you hear on Star Trek?

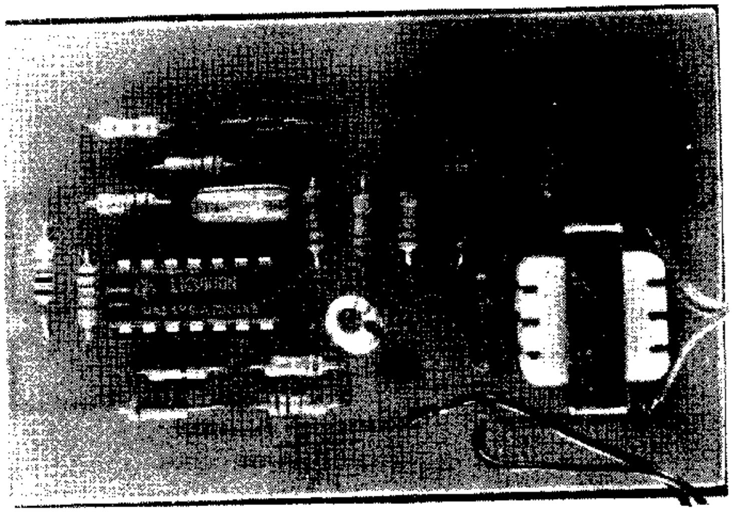
While our Road Runner is not as versatile as most music synthesizers, it is a relatively simple circuit that will deliver good results.

This circuit was originally intended for automotive use and to this end you will require an additional power horn and amplifier (such as the one in Mar '77 ETI Tech Tips). The Road Runner will work quite happily on 12 Volts.

Additional sound effects can be achieved by various modifications to the basic circuit. Try joining points A & B with a 330n capacitor. Alternatively, use a 330n capacitor to join point A to pins 1,3,4,5,7,8,9,10,11,12,13, & 14 on the IC, or point B to pins 1,2,3,6,8, 11, & 13. Some connections will only produce a change in pitch, while others will produce a distinctive warble or other variation of the modulation.

To simplify assembly, we recommend you use the pc pattern shown, but Veroboard or perforated board work just as well. It is also advisable to use a socket for the IC to prevent heat damage during soldering.

All parts can be assembled using the component overlay given. Needless to say, you should check the orientation of the IC, transistors and any other polarized components before applying power to the circuit.



HOW IT WORKS

Before we even get started on the circuit itself, it's important to understand how the "op amps" in the LM3900 work. They are not ordinary op amps in that the input signals are currents rather than voltages. This is shown in Fig. H1. There, we see the amp as it appears from the outside. The inputs look like diodes connected to the negative (or ground) supply. The output voltage is : $V_o = A(i_+ - i_-)$, where A is very large. In otherwords, if Vo is to be any reasonable value (between the two supply voltages) the two currents must be about equal. Which leads us to the revelation that this amp is almost always used with feedback circuitry such that the output voltage adjusts to the point where the feedback makes the currents equal, or , as with regular op amps, the feedback circuit is really what determines the overall circuit action. The other way of operating this circuit is as a "comparator", that is to say, if i_+ is more than i_- the output is high (+ Supply −0.8V), and vice versa: output "low" (−Supply +0.2V).

Finally, since most people are unfamiliar with currents as signals, it's convenient to use voltages as inputs by putting a resistor in series with the inputs. This may seem a little hard to grasp at first, but you can see that (Fig. H2) the input currents will be proportional to the input voltages (less 0.6V).

SOUND EFFECTS

Starting with an overview of the circuit we have something like Fig.H3. The voltage controlled oscillator (Q2 and T1) produces the basic tone you hear, and it is frequency modulated by the input voltage from the wandering voltage generator (IC1b,c) which in turn is varied by the low frequency oscillator IC1a.

Looking at IC1a, C1 will initially be discharged, hence current will not be flowing into pin 3, but only into pin 2. This means pin 4 will be "up", in turn attempting to charge C1. Consequently, the voltage across R1 will rise, increasing the current into pin 3. Eventually , it will rise to equal or excede the current into pin 2, at which point the output (pin 6) will go low. (Note that as this happens R4 previously contributing current to pin 2 is now diverting it away. This action makes the transitions quick and sharp. It is positive feedback, and is an example of "hysteresis".) Now it will be seen that the opposite happens, R2 discharging C1 and so forth. So we have an approximately square wave generator, with output swing of about 8V.

IC2b acts as an "integrator". The easiest way to think of this is to say that the difference in input currents ends up in C2, so that the output voltage is $V_o = (i_+ - i_-)\ t/C2$. Obviously this can't go on for ever, as after a certain length of "t" Vo would try to excede the power supply voltage, hence the purpose of IC1 c.

Initially, suppose the output of IC1b is high, IC1c output will be low and thus Q1 will be off. Also assume that IC1a output is high. Current thus passes from IC1a through both R5 and R6, into + and − inputs of IC1b. Since R6 is half the value of R5, twice the current flows into the − input, and the output of IC1b will ramp down until it reaches the point where IC1c output goes high. Now Q1 turns on diverting the current which was going to pin 11. Thus IC1b will start to ramp up, and so on.

The amplitude at the output of IC1b is obviously determined by the turn on and off points of IC1c. The appropriate current values at the + input to IC1c are (with 9V supply) 8.4V/1M and 8.4V/1M + 7.6V/510k which are: 8.4uA and 23.3uA (note the hysteresis action again!). These will be provided through R8 (330k) when the voltage at pin 10 is 2.8V and 7.7V.

The actual output waveform from IC1b is a ramp when IC1a is high, and "hold" (flat) when IC1a is low (no input current to IC1b). IC1a has to go high about five times to take IC1b from one threshold point to the other. So, overall, the output from IC1b looks like a series of ramp and holds up, then another series down etc, with repetition every second or so.

This voltage is buffered by IC1d, and then used to control the base current of Q2. Q2 is an oscillator with feedback via the "top" half of T1, C4, C3, and R14. Frequency is controlled by the base current. Finally, the speaker is driven from the secondary of T1.

Many strange sounds can be made by this device by connecting wires, capacitors, resistors or fingers between varous points in the circuit. The basic action is to alter the shape of voltage "sequence" which controls the frequency. (Care should be taken not to directly connect IC outputs to either supply line, each other or to the IC inputs, and IC inputs must not be directly connected to the + supply.

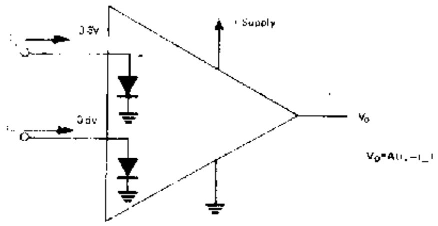


Fig. H1. How the LM3900 type op-amp looks to the outside world.

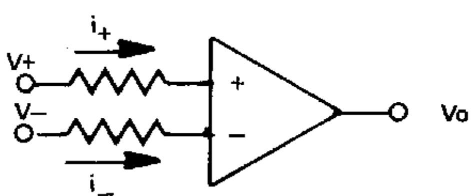


Fig. H2. Input resistors turn input voltages to input currents.

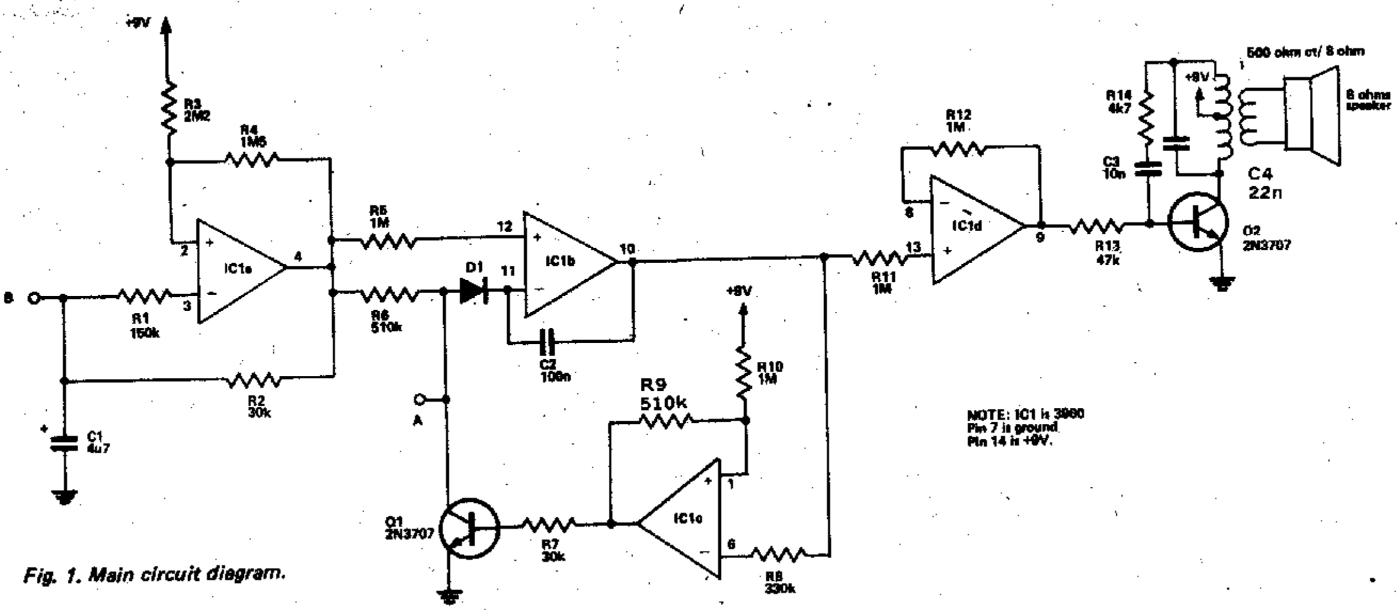


Fig. 1. Main circuit diagram.

Component layout

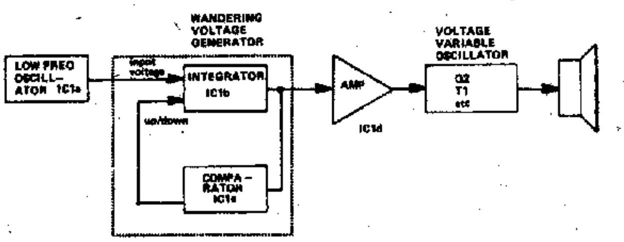
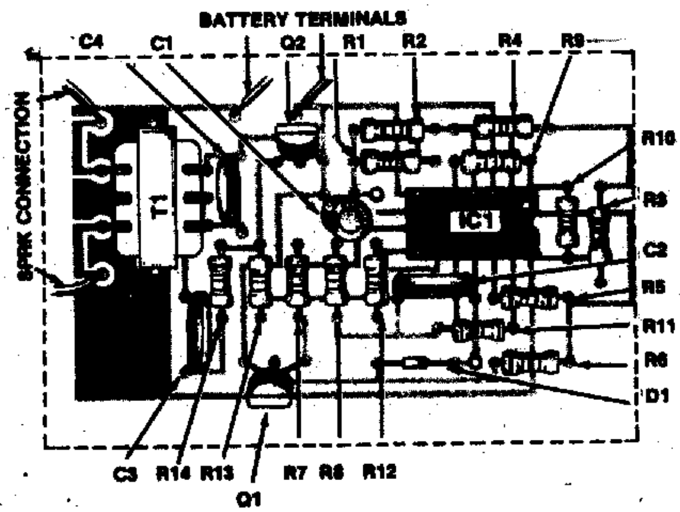


Fig. H3. Block diagram showing functional sections of circuit.



PARTS LIST

ROAD RUNNER PARTS LIST

RESISTORS

R1	150k	¼W
R2,7	30k	¼W
R3	2M2	¼W
R4	1M5	¼W
R5,10,11,12	1M	¼W
R6,9	510k	¼W
R8	330k	¼W
R13	47k	¼W
R14	4k7	¼W

CAPACITORS

C1	4u7 16V electrolytic
C2	100n mylar
C3	10n
C4	22n

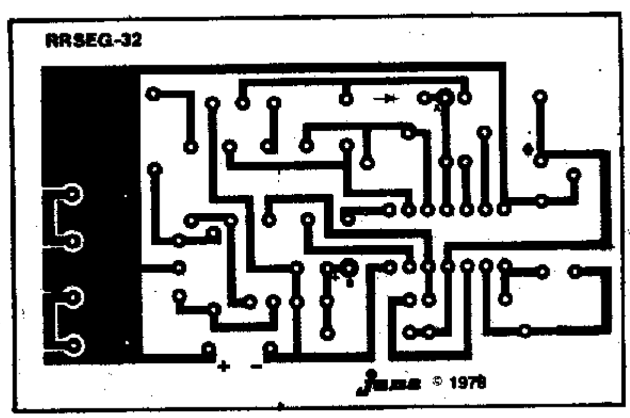
SEMICONDUCTORS

IC1	LM3900
Q1,2	2N3707

MISCELLANEOUS

T1 audio transformer 500R CT pri. to 8R sec.
case, solder, wire, earplugs, etc.
8 ohm speaker.

This project is available as part of the Jana line of kits. See page 67 for details.



Printed circuit board foil pattern.