A TORNADO EARLY-WARNING SYSTEM

www.gernsback.com

SEPTEMBER 1999

Electronics NOW®

The Wild Mouse

Tailor the sound of your guitar with this easy-to-build effects box

PIC Assembly Language for the Complete Beginner

Here's how to get with the "program"

Digital Frequency Displays

Build one and add it to almost any piece of radio or test gear

Build a Phono Adapter

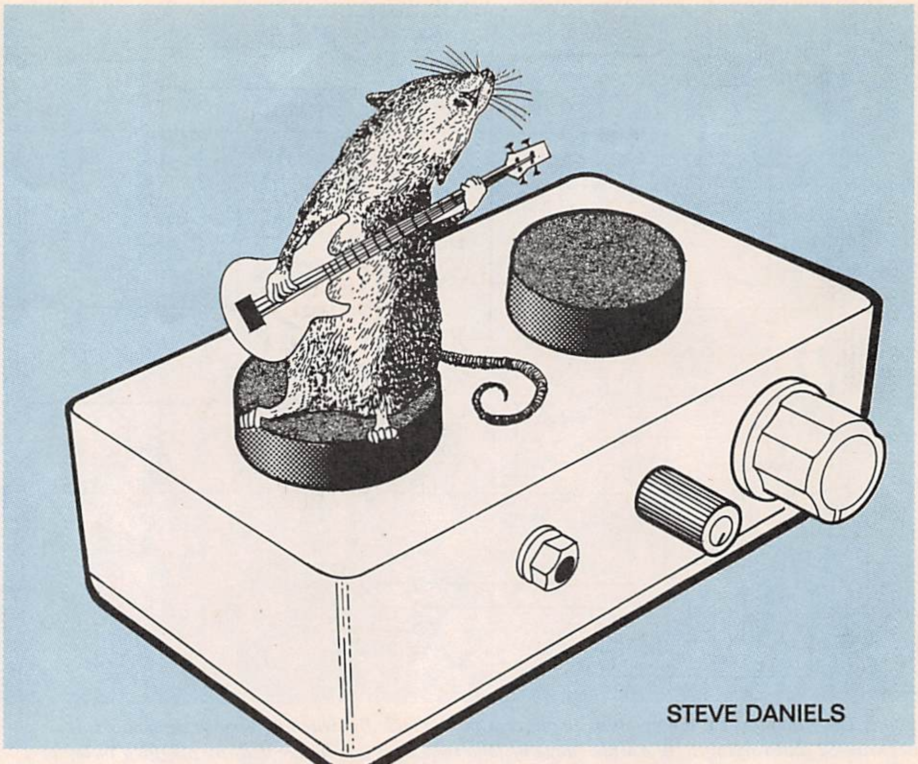
Reclaim that unused phonograph input on your stereo receiver or amp

A GERNSBACK PUBLICATION

$4.99 U.S.
$5.99 CAN.

The Wild Mouse

Expand the types of sounds from your guitar with this simple "effects" box.



STEVE DANIELS

Thanks to falling prices for music-related electronics such as guitar sound effects, many different types of guitar pedals and boxes are available at very reasonable prices. Still, for those of us who enjoy both playing guitar and "rolling our own" electronics, tailoring the sound of our instruments with home-brewed effects remains a uniquely satisfying merging of both pastimes.

One basic type of circuit that is used for a variety of guitar effects is an active tone boost. That type of circuit is inexpensive to build from readily available components and is the basis of the Wild Mouse project presented here. It can be used to produce a variety of sounds from "twangy" to muffled. By switching the circuit in and out, the guitar's sound can instantly switch from lead playing to unmodified rhythm playing. The intensity of the effect can be varied by a potentiometer; an external control can also be used. Controlling the Wild Mouse with an expression pedal will yield "wah-wah" effects; a function generator can be used for automatic sweeping.

How It Works. The schematic diagram for the Wild Mouse is shown in Fig. 1; refer to it during the following discussion.

Audio from a guitar or other musical instrument is applied to J1. If S1 is in one position, the signal is sent directly to J2, bypassing the Wild Mouse circuit. With S1 switched the other way, the signal is coupled through C6 to IC1-a. The gain of that stage is set by R2.

For the moment, let's assume that R2 is set to its highest resistance; furthermore, the network formed by C1–C4, R10, and L1 are not a part of the circuit. With the values of R1 and R2 the same, IC1-a is a simple voltage amplifier with a gain of 1. If R1 were to drop in value or be bypassed, the stage gain would rise in proportion to the decrease in resistance to ground.

The circuit formed by C1–C4, L1, and R10 is a tuned circuit with a resonant frequency on the order of 1 kHz. That network bypasses R1, but does so most strongly around the resonant frequency or a harmonic of it. At those frequencies, the gain of the stage increases tremendously. Because of that gain increase, R2 is adjusted to clamp the gain to a point just below where the circuit would start oscillating. The result is a frequency-selective amplifier.

When used as a straight tone boost, R10 is adjusted for the amount of influence the resonant circuit has on the frequency response of the stage. In addition, one of the capacitors, C1–C4, is selected by S2. The result is that the tone can be adjusted between a more twangy or a more "muffled" effect. The tone-boosted output of IC1-a is further amplified by IC1-b. The amplified output is fed back through C9 and R9 to sharpen the peak of the frequency response.

Note that R10 is connected to the circuit through S3. That switch allows an external resistance to be connected through J3 to the circuit in place of R10. That way, an expression pedal or a function generator can be used in place of R10; that is how the "wah-wah" effect is produced. Sweeping the resistance more slowly and over a narrower range produces either a vibrato effect similar to a Leslie speaker or a spacey effect similar to phasing. For those who are not familiar with the name, a Leslie speaker is a speaker that is mounted on a motorized turntable; the setup is somewhat like a sound-based lighthouse. As the speaker begins to face away from the listener, the phase of the sound seems to undulate. While it is difficult to describe

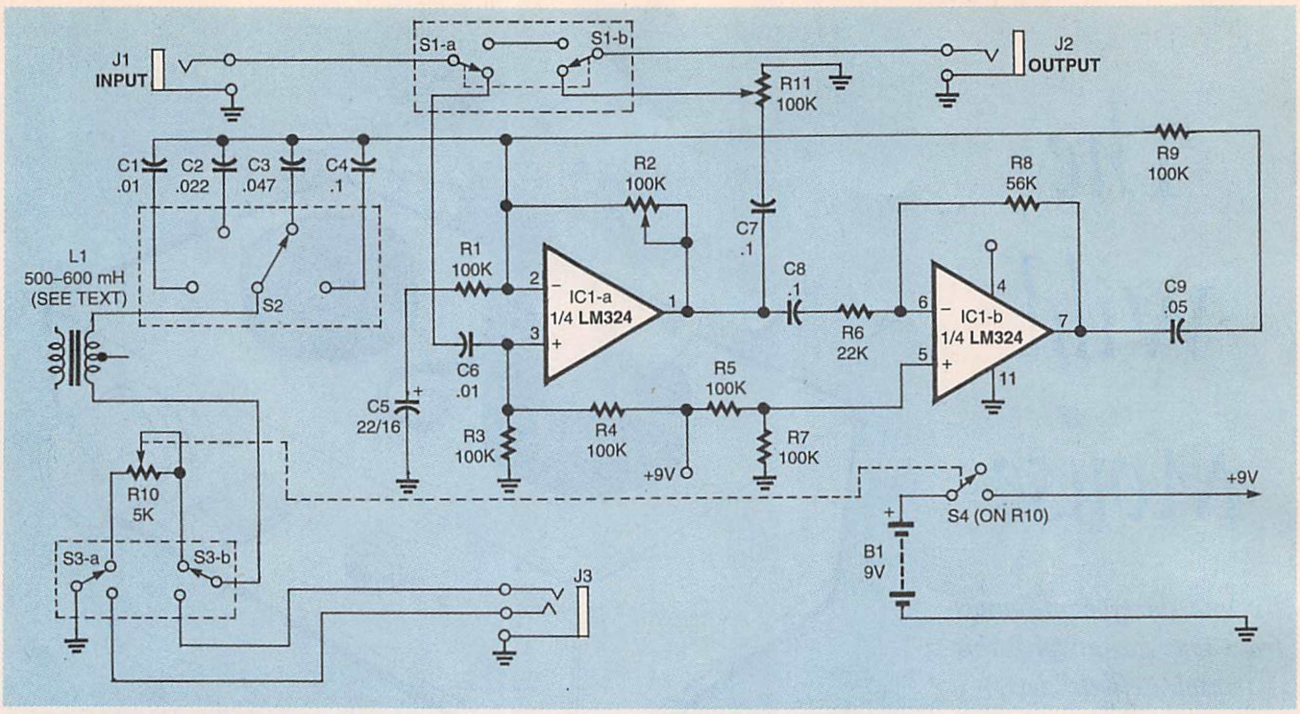


Fig. 1. The Wild Mouse is a tone-boost amplifier with feedback. By switching various capacitor values with S2 and varying R10, a wide range of tone responses can be created. By plugging in an external resistance such as a foot pedal to J3, the Wild Mouse can be used as a "wah-wah" effect.

the effect, it is very easy to recognize it once it is heard.

The modified output is coupled to J2 through C7. Potentiometer R11 keeps the overall amplification of the Wild Mouse from overdriving any amplifier connected to J2; guitar pickups vary in output from model to model and all amplifier inputs are not equally sensitive. The raw output level of the Wild Mouse can be quite high and might overdrive some amplifiers.

The Wild Mouse is powered by a 9-volt battery that is switched by S4.

Construction. Due to the noise-sensetive nature of audio circuits, the Wild Mouse is best built on a printed-circuit board to help cut down on any stray noise pickup. Foil patterns have been included here. A pre-etched and drilled PC board is also available from the source given in the Parts List. If you use that board or etch one from the foil pattern, use the parts-placement diagram in Fig. 2 when populating it.

Note that the PC pattern was designed so that the suggested parts for S1, S3, S4, and R10 could be mounted directly to the board. If you are using components that are different in physical size, you might have to mount them to the case and connect them to the PC board with short lengths of insulated wire. Another unusual aspect of S1 and S3 is that while the switches themselves are symmetrical with respect to their pins, they have mounting tabs that are *not* symmetrical. Unconnected pads are included in the foil pattern to locate those mounting holes; simply drill them out to match the

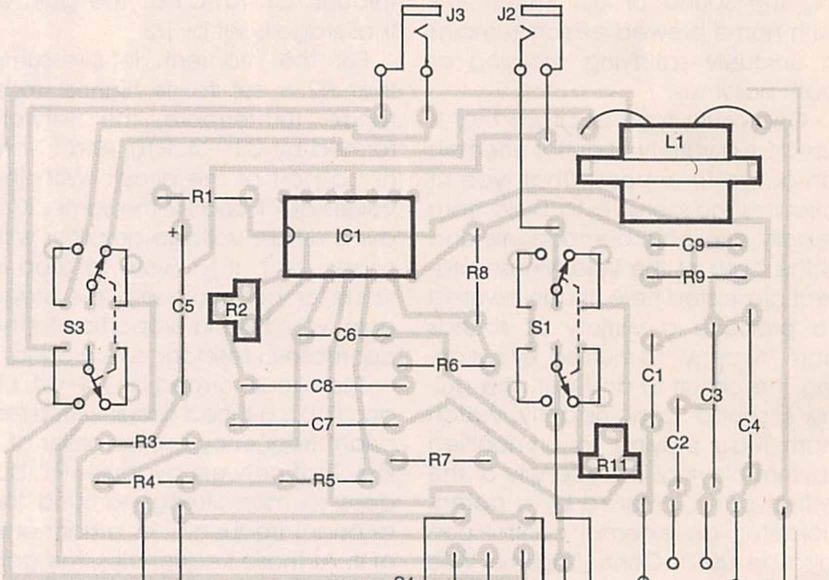


Fig. 2. The Wild Mouse is simple enough to be laid out on a single-sided board without the need for jumpers.

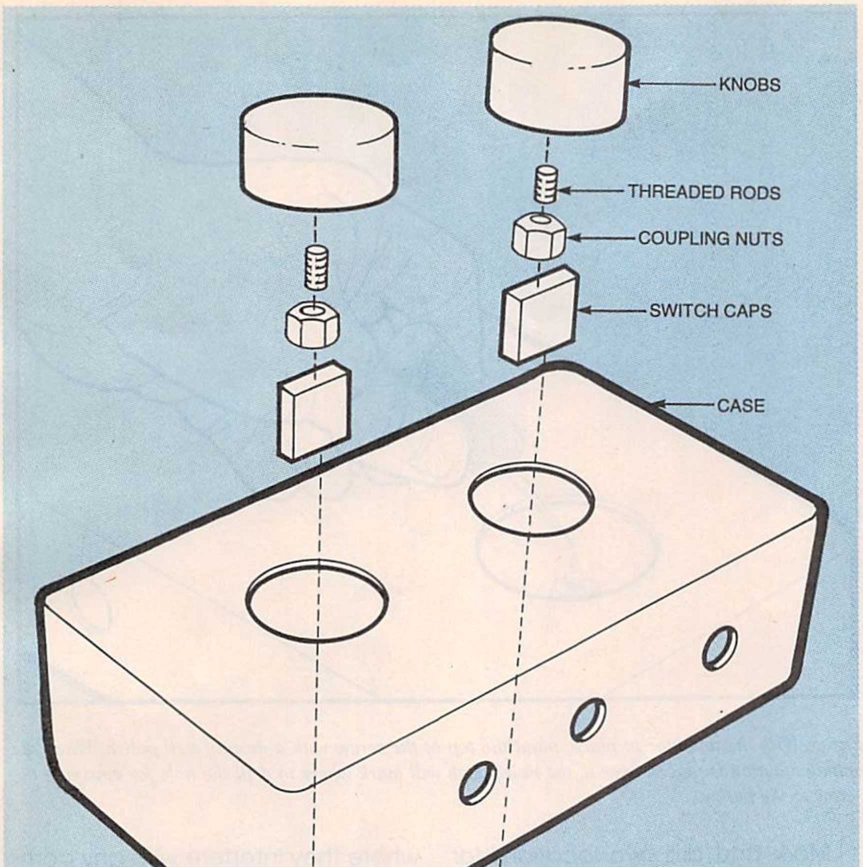


Fig. 3. The entire Wild Mouse fits into a small box. With a strong enclosure and robust actuators for S1 and S3, the Wild Mouse can be used as a foot-controlled "stomp box."

mounting tabs.

Also note the unusual source for L1. The advantage of using one side of an audio transformer instead of a choke is that the part specified is readily available, cheap, and works well. While a true 500-mH choke produces (to the author's ears, anyway) a slightly more mellow sound, it was much too physically large to be used in the prototype's case.

The rotary switch specified for S2 is an off-the-shelf item from RadioShack. Using such a two-pole, six-position device for a one-pole, four-position requirement has the advantage of low cost, wide availability, and most importantly, small size. The potentiometer/switch combination recommended for R10/S4 is small enough to make for easy assembly, but bear in mind that it has a 1/8-inch shaft rather than the more usual 1/4-inch variety. Suitable knobs are available, but they might be a bit more expensive. If you want the knob for R10 to be at the same level as S2, you will need to mount R10 somewhat above the board; flush-mounting R10 will result in the controls not being even. Also note that the shafts for the controls should be cut down to a length of about 1/2 inch before soldering to them.

The jacks, S2, and the battery clip for B1 are connected with lengths of insulated wire. Once the wires are soldered to the PC board, a dab of epoxy makes a good strain relief; those wires might be stressed during final assembly and subsequent replacements of the battery. Once everything has been soldered, examine your work carefully for any construction errors such as cold-solder joints, broken wires, missing or incorrect parts, or polarized components that have been installed backwards.

Testing. The Wild Mouse is easiest to test before mounting in a case. Connect a 9-volt battery to the battery clips and an amplifier to J2. Set S3 so that R10 is connected to the circuit. With R2 set to its minimum resistance and the amplifier at low volume, turn R10 (switching S4 on) up to about / of its rotation and press S1. With a small screwdriver, slowly raise the resistance of R2. At some point, you should hear very loud feedback. Back off slightly from that setting. Rotate R10 from maximum to minimum resistance, and you should hear a rushing sound that varies in pitch as the resistance is lowered. You can now connect a guitar to J1 and see how the effect sounds before working on the case.

Troubleshooting. The Wild Mouse is a simple circuit; very little can go wrong. Should there be some sort of problem, it is most often caused by—in the author's personal experience—a wiring error. If you etched your own PC board, check the continuity of every connection with an ohmmeter. Be sure that all resistor values are correct and that the right values are in the right places. Use a voltmeter to make sure that pin 4 of IC1 is getting 9 volts and that pins 3 and 5 are each getting about 4.5 volts. If the unit passes all of those checks turn out fine and you still have trouble, break the feedback loop by disconnecting C9 temporarily. Use a guitar amp as a signal tracer and see if you can find where the signal is being lost. You should hear a boosted signal at pin 1 of IC1, but without the sharpness that feedback adds. You should hear the same signal, but louder, at pin 7. If those tests pass, reconnect C9 and continue troubleshooting the feedback loop. Once any problems are cleared up, you can finish construction of the Wild Mouse.

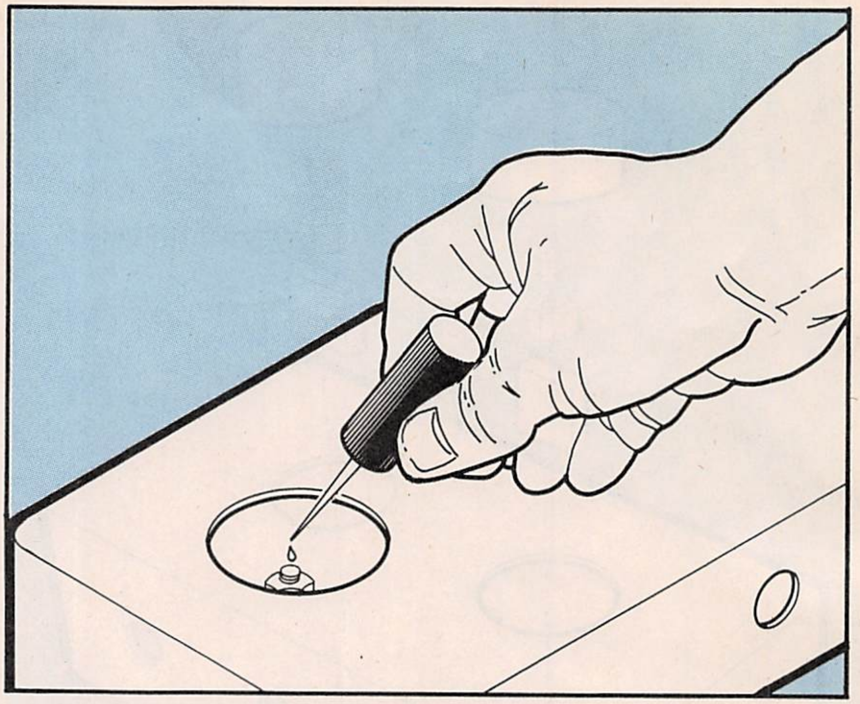


Fig. 5. With the actuator in place, paint the top of the screw with a drop of nail polish. When the actuator button is placed over it, the nail polish will mark where to drill the hole for epoxying the screw to the button.

Final Assembly. The Wild Mouse should be mounted in a rugged case that can take being stepped on and kicked around on stage. The author's prototype used a cast aluminum box. That case (Jameco no. 11965) is small, very rugged, and gives the unit a compact, professional appearance. Note that if you have made substitutions of components such as switches and controls, you might have to use a case that is larger. In any event, the case that you use should be strong.

The general arrangement of the Wild Mouse parts is shown in Fig. 3. Note that the PC board is mounted to the lid of the case and that the case itself is used as a "cover." Using the case upside down gives the Wild Mouse a more "jazzy" look, and as any musician will tell you, style is important.

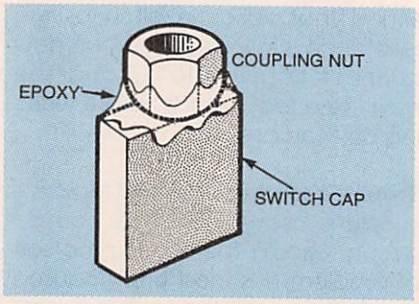


Fig. 4. The actuators are made from a snap-on switch cap with a short coupling nut that's epoxied to it.

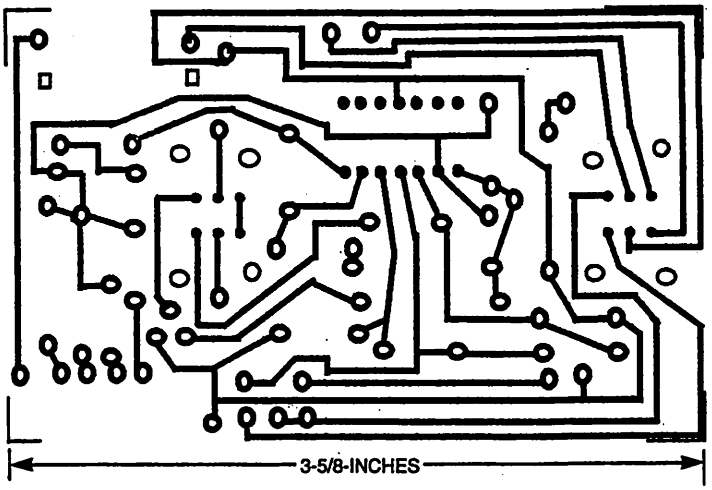
Mark and drill two locations for mounting screws on the lid and the PC board. The screws are mounted to the lid with nuts, which will act as standoffs for the PC board. Before securing the board in place with two more nuts, mark the locations of S1 and S3. Cut down two adhesive rubber feet to the thickness of the "standoff" nuts. Attach those "backstops" to the inside of the lid so that they will be directly underneath S1 and S3 when the PC board is in place. That will give the PC board some protection from being accidentally flexed should someone activate one of the switches a little too enthusiastically. Fasten the board down, checking that the backstops are not so high as to bend the board; file them down if necessary.

Drill holes in the case for the jacks and switches. The locations of most of those parts are not critical as long as there is clearance within the case; the exception is R10/S4. Since that component is mounted to the PC board and the PC board is mounted to the lid, you must drill its mounting hole accurately. If you are working with a case that has structural ribs cast into it, don't forget to file or grind them smooth where they interfere with any components being mounted to the case.

Once it is mounted within its case, it would be a good idea to check the Wild Mouse again to make sure that nothing has gone wrong in the process such as broken wires or short circuits. Before closing the case, check that S1 is down and S3 is up. Once you're sure that everything works, it's time to work on the actuators for S1 and S3.

"Feetswitches." Providing rugged, inexpensive, compact, true-bypass switching for a musical-instrument sound effect has always been problematic. One method used by some manufacturers is to use a light-duty switch and a robust actuator that is often a part of the case itself. That method was adapted for the Wild Mouse in a way that needs little machining; some common bits of plastic and epoxy produces usable results.

The switches specified for S1 and S3 are used for instrumentation applications. They provide double-pole double-throw switching in a push-on/push-off arrangement and are designed to mount directly on a PC board. A variety of snap-on



Here's the foil pattern for the Wild Mouse. Note the pads that do not have any traces connected to them. Those pads indicate where mounting holes are to be drilled for S1, S3, and L1. Also note that the mounting holes for the switches are not symmetrical.

caps are available for them; the suggested unit makes a good basis for an actuator.

Start by opening the Wild Mouse and snap the caps on to S1 and S3. Measure the exact positions of the centers of the caps with respect to the edges of the lid, and use these measurements to mark the points on the cover for the centers of the large holes.

The ideal tool for making those holes is a punch, such as a Greenlee socket punch. Those punches come in various sizes and shapes; use a diameter that is slightly larger in diameter than the buttons that you will be using. It is also possible to use a nibbling tool; make each hole slightly smaller than the diameter of a button (more on that in a moment), enlarging them to the correct size using a small file with a curved edge. Test the diameter of the hole by holding a button against it until the button just passes freely.

The buttons that were used in the prototype Wild Mouse are 1-1/8-inch-diameter by 3/8-inch thick acrylic discs. Such discs can be found in a well-stocked plastic-supply house. An alternative is to use a bottle cap from a cardboard juice container. Fill the cap with layers of epoxy or auto-body filler until it is completely filled. File the bottom "lip" off the cap and the button is ready for use in the Wild Mouse.

Roughen the surface of the switch caps and the outside of a pair of 4-40 by 1/4-inch coupling nuts with fine sandpaper. Mix up a small amount of quick-drying epoxy and apply a small dab to the top of the caps. Place the spacers into the glue. With the cover in place, center the spacers to the button holes as closely as you can. The completed caps should look like the illustration shown in Fig. 4.

When the epoxy is dry, run a 4-40 by 1/4-inch screw finger-tight and all the way into the spacers. Place a tiny dab of nail polish on the screw head (see Fig. 5). Drop a button gently on the screw; the nail polish will mark the position of the screw head.

Drill a hole in the bottom of the button where the nail polish marked it. The diameter of the hole should be just large enough to fit the screw head; 7/32-inch should do for a 4-40 screw. Drill the hole as close to perfectly vertical as possible. The depth should be about 1/3 to fi of the button's thickness.

Clean the nail polish from the screw heads. Screw them back into the coupling nuts and apply a dab of epoxy to the heads. Place the buttons over the screws, clamping them in place until the glue sets. Be sure that the button is as close to parallel with the top of the case as possible and centered in its hole. When the glue has set, test the assembly by pressing the button gently once or twice. The button

PARTS LIST FOR THE WILD MOUSE

RESISTORS

(All resistors are 1/4-watt, 5% units, unless otherwise noted.)

R1, R3–R5, R7, R9—100,000-ohm
R2, R11—100,000-ohm trimmer potentiometer, PC-mount
R6—22,000-ohm
R8—56,000-ohm
R10—5000-ohm potentiometer with integral single-pole, single-throw switch, panel-mount (Digi-Key CT-2226 or similar)

CAPACITORS

C1, C6—0.01-µF, Mylar (see text)
C2—0.022-µF, Mylar (see text)
C3—0.047-µF, Mylar (see text)
C4, C7, C8—0.1-µF, Mylar (see text)
C5—22-µF, 16-WVDC, electrolytic
C9—0.05-µF, Mylar

ADDITIONAL PARTS AND MATERIALS

B1—9-volt battery
IC1—LM324 quad op-amp, integrated circuit
J1, J2—1/8-inch mono phone jack, panel-mount
J3—1/8-inch stereo phone jack, panel-mount
L1—500- to 600-mH choke (RadioShack 273-1380—see text)
S1, S3—Double-pole, double-throw switch, PC-mount (DigiKey EG-1016ND or similar)
S2—Single-pole, four-throw rotary switch (RadioShack 275-1386—see text)
S4—Single-pole, single-throw switch (part of R10)
Case, knobs, switch caps (Digi-Key EG-1088-ND), wire, hardware, etc.

Note: The following items are available from Small Bear Electronics LLC, 123 Seventh Ave, Suite 156, Brooklyn, NY 11215: Kit of all parts including etched PC board and unfinished case except for actuator materials, $31.25; Etched and drilled PC board, $6.00. Add $6.00 to kit for substitute S2 with 1/2-inch shaft. Please add $6.00 for shipping/handling on kit; $1.00 for PC board. Priority Mail is available on PC board for $3.00. New York State residents must add 8 1/4% sales tax.

should not bind at any point. If the actuator works freely, unscrew the buttons gently; do not get them mixed up. Fill in the screw hole with some more epoxy so that it is level with the surface of the button. Be careful not to get any glue on the screw threads that are not within the hole. When the glue has set, screw the button back on and test them again. If everything is okay, unscrew the buttons once again, take the cap off the switches, and add more epoxy around the spacer and coupling nut to reinforce the bond.

With the Wild Mouse complete, the finishing touch is to clean up the case and finish it as you see fit. When everything is done and the unit reassembled, the Wild Mouse is ready for use.

Using the Wild Mouse. Most of the ways to use the Wild Mouse have already been mentioned. For those who would like to experiment with phasing and "wah-wah" effects, here are a few quick suggestions.

The most important factor for getting a good live wah-wah sound is being able to drop the resistance in the tank circuit from about 5000 ohms to as close as possible to zero with a relatively small vertical movement of a pedal. If you have a potentiometer-based pedal, use an audio-taper pot of 5000 to 10,000 ohms. If your pedal uses an LED and a photocell, the LED should be bright; the photocell needs to have the lowest possible "on" resistance.

You might find that raising the resistance of R2 slightly past the point of initial calibration results in a better wah-wah effect. While that introduces more background noise, it sharpens the peak of the response. Your setting for R2 will depend on your most common application as well as personal taste.

For phasing, vibrato, or Leslie effects, a relatively low-resistance photocell and high-brightness LED will work well. An interesting method to slow the speed of change is with the use of incandescent lamps. Process the audio signal through several Wild Mice (Wild Mouses?) and then mix it with the original unmodified signal; the result is a stereo chorusing effect. Try triggering an envelope generator (a circuit that generates a signal shape when triggered) from the guitar input, use the result to drive an LED, and put the LED in front of a photocell on the external control input: Auto-Wah!

After using the Wild Mouse for a while, you might start to hear hissing and popping. That is the first indication that the battery is getting weak and needs to be replaced with a fresh one!

As you explore all that the Wild Mouse has to offer, no doubt you'll come up with some amazing sounds yourself. If you have any comments or suggestions, the author can be reached at stevedanls@aol.com. Ω