A SENSITIVE, RELIABLE INEXPENSIVE TOUCH DETECTOR

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Research in our laboratory required a sensitive, reliable, inexpensive touch detector for use with rats to test the reinforcement of inhibition (e.g., Anger, 1983). A small touch detector was also desirable so that the detector could be mounted on the rat's cage close to the object being touched by the rat, whose touches in turn were being detected by current passing through the animal, thereby reducing the influence of other signals. The commercial units available required 50 MΩ or less to trigger them. Such sensitivity often would not detect a rat touching a metal object with its paws. Moreover, commercial products such as Coulbourn's Contact Circuit (Product #H24-05) and Columbus's Lick Counter (DM-8) cost $195 and $182.50, respectively, per unit. A detector was desired that would detect several hundred MΩ, and directly operate a multipole relay. Earlier attempts to develop such a detector used seven transistors, but those units became unreliable due to transistor failure. It seemed desirable to minimize the number of components.

Operational amplifier chips are extremely sensitive, but produce low outputs. The Darlington amplifier chip has tremendous amplifying power. The combination of just those two chips was ideal for this problem (see Figure 1). The common operational amplifier LM741 (LM741CN, Newark InOne, Catalog #07B6949) feeding into a Darlington TIP120 (Radio Shack, Catalog #276-2068) could operate a 200-Ω mercury-wetted 6-pole relay. The transistors and other components were soldered on small circuit boards, some as small as 5.7 cm by 4.4 cm, and then covered with silicon embedding material to protect them from moisture, dust, and materials from the rat (see Figure 2). A small hole covered with thin transparent plastic can be made in the embedding material above the 741 operational amplifier so that the chip (which was in a socket) could be changed. Alternatively, the circuit could be housed in a casing rather than being embedded in silicon. The unit operated on the usual 24 volts DC. A 200-Ω relay is sketched in the diagram in Figure 1, but a variety of relays could be used.

The sensitivity of different units varied widely. This was largely due to variation in the 741 operational amplifiers. The 741s were purchased from Radio Shack. Twenty- five of the 741s were purchased and tested in one detector unit. The measure of sensitivity was the highest MΩ at which the relay stayed operational 100% of the time. The sensitivity with the 25 chips varied from 150 to 730 MΩ. Chips were packaged in clear bubble wrap attached to a card. The card listed the names of several countries of possible origin. Many chips were labeled with three letters such as ''CHN'', ''MAL'', etc. These abbreviations referred to country of origin. Currently, the chips have the entire country name on the chip and/or card. The sensitivity was highly correlated with these symbols. Those marked CHN ranged from 540 to 730 MΩ; those marked MAL ranged from 400 to 640 MΩ. Most of the other chips ranged from 150 to 280 MΩ. For some purposes maximum sensitivity was desirable, but for other applications less sensitivity was preferable. Variability in the chips requires fine tuning by changing resistance values to improve or ensure operation. The detector has capacitance limitations just like any detector, but merely needs adjustment in the amount of resistance to suit one's particular needs for detection purposes. The circuit must be electrically isolated. If a battery is used for the power supply then the circuit will be isolated. If a source of direct current is

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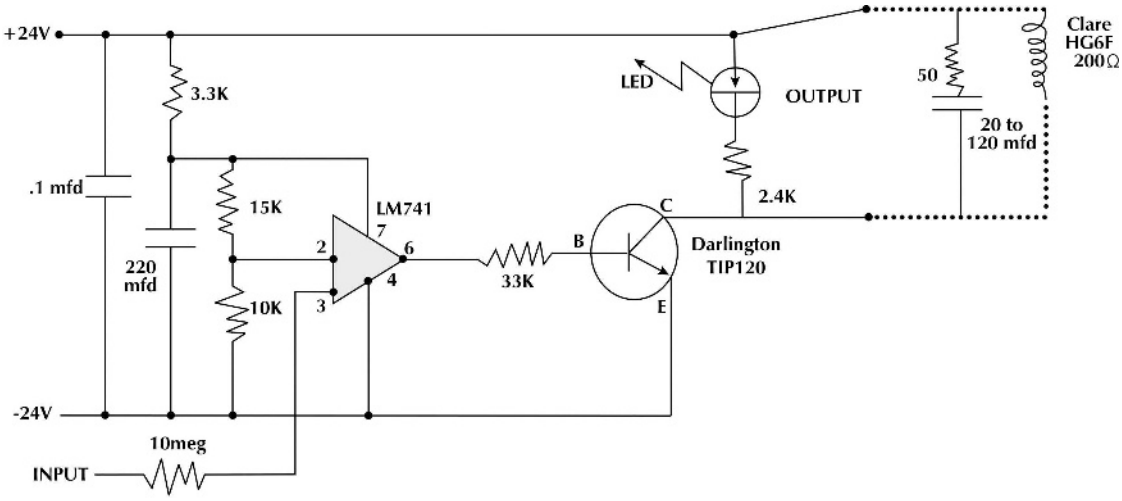

Fig. 1. Circuit diagram of touch detector.

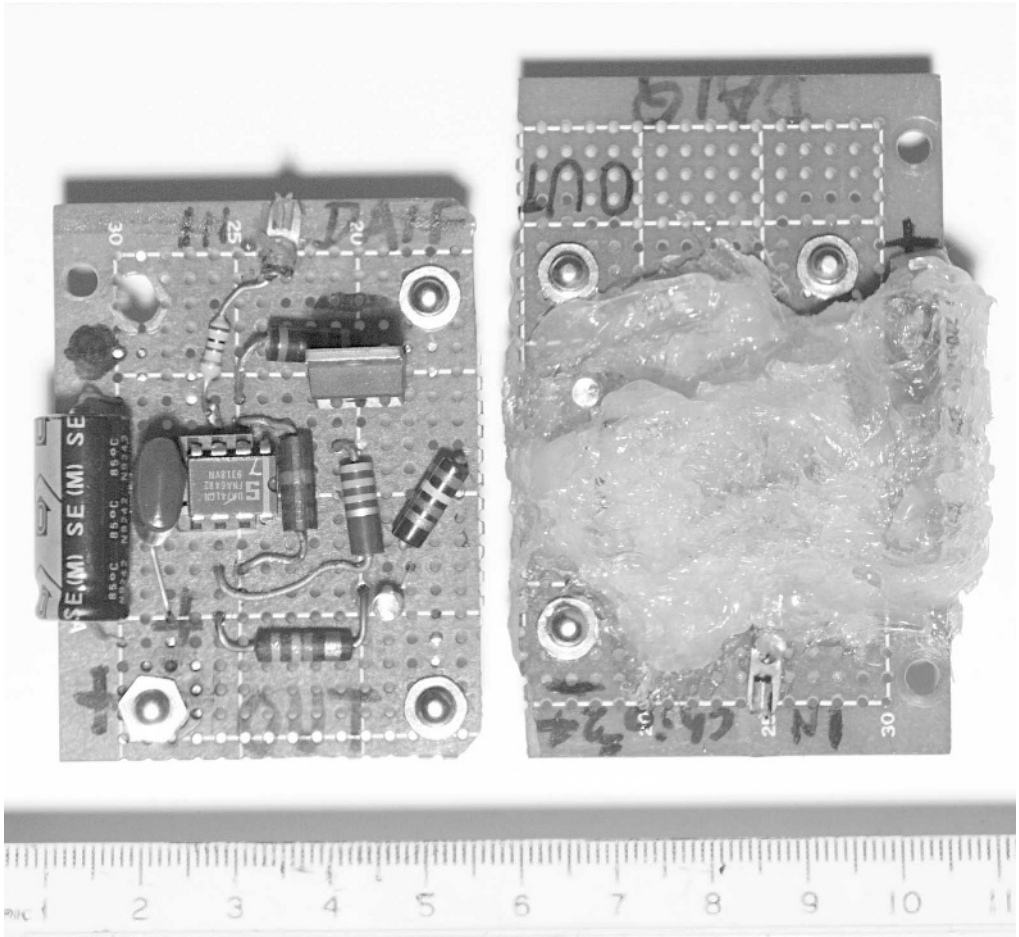

Fig. 2. Two touch detectors. The unit on the left is shown before embedding. The unit on the right is slightly larger to simplify its mounting and it is embedded.

used by a transformer, then an isolating transformer should be used and the -24 V should be at zero volts rather than ''building ground''. The manipulandum must also be electrically isolated.

An experienced electronic engineer today probably could design a much better detector than this amateur design, but to our knowledge that has not occurred. A circuit such as this one is very universal and is a basic building block of electronic amplification. It can be used to detect touch, licking, photocell detection, and other contact-related measures in rats as well as humans and other animals. Of course, sensitivity depends on many factors including the amount of moisture and how much animal tissue makes contact with the manipulandum. Six of these units operated for several years without failure. The estimated cost per unit is $7.50.

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