An apparatus for the detection and counting of mouse squeals*

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An instrument, designed to detect and count mouse squeals and to reject other sounds which might confound the data, is described. A parts list is furnished.

Loud vocalizations from rats and mice have frequently been noted in connection with the aggressive behavior of these organisms. Hall (1941) listed squealing as a reaction assumed to be aggressive in rats and mice, and Kahn (1951) noted squealing in a study of the effects of defeat on further aggression. In this connection, Scott and Fredericson (1951) mention that when a mouse is bitten, it squeals and runs away. One line of research on the effects of morphine-induced aggression (Thor & Hoats, 1970; Thor, Hoats, & Thor, 1970) has utilized the loud vocalizations of rats as the only dependent variable. The apparatus used by these researchers was simply a voice-operated relay adjusted to be actuated by relatively loud (90-dB) sounds; however, this apparatus may have allowed sounds other than the squeals to be detected, since it was operated without frequency-limiting equipment.

The proposed instrument was designed specifically to detect and count mouse squeals and to reject other sounds which might confound the data. Although the device was constructed to detect mouse squeals specifically, minor adjustments allow it to be used with rats.

THE APPARATUS

The major component of the apparatus is the detector circuit shown in Fig. 1. A parts list is provided in Table 1. The signal is picked up by a crystal microphone and fed into Integrated Circuit 1 (IC 1), which functions as an amplification stage. The gain of the amplifier is set by the 10K pot associated with IC 1 and serves as the fine adjustment of sensitivity to input signals.

ICs 2, 3, and 4, with their attendant components, function as the filter

section which attenuates all signals outside the range of the squeal. The audio frequency of the squeal was determined by measuring mouse squeals with a memory-type oscilloscope. The squeals were found to range primarily from 3,500 to 4,500 Hz, with the heaviest concentration in the 4,000-Hz range. Empirically, it was found that an audio bandpass filter with a center frequency of 4,000 Hz was most effective in limiting sounds other than squeals. A 50K variable resistor (preceding IC 2) sets the overall gain in the filter, and the center frequency is set by the 10K-ohm pot. The Q of the filter, or the width of the bandpass, is set primarily by the 1-megohm resistor between Pins 2 and 6 of IC 2. IC 5 is an additional amplification stage whose output is fed into IC 6, which functions as a detector. The detector compares the voltage of the amplified input signal with a reference voltage supplied through a voltage divider consisting of the 10K-ohm resistor and any one of the 5,100-, 3,600-, 2,400-, or 1,500-ohm resistors, as selected by the rotary switch. The switched voltage divider provides reference voltages of 5, 4, 3, or 2 V, depending upon the resistor chosen. This adjustable reference voltage provides for rough selection of sensitivity ranges, since the input signal must exceed the reference voltage to cause a response in the detector. Fine levels of sensitivity are set by the 10K pot of IC 1. If the signal strength of the input exceeds the reference voltage, IC 6 triggers IC 7, which in turn switches the transistor (No. 2N3643) on. In its "on" condition, the transistor makes a completed path to ground through the coil of the reed switch, causing the switch to close. A double-pole reed switch was chosen to provide a switch closure for a counting mechanism, and a second switch closure operates a pilot light which indicates when a count has been registered. The entire circuit was built on perforated board (2½ x 17 in.), using Vector clips and point-to-point wiring. This board was mounted on a 3-in. relay rack panel within an aluminum chassis and side

panels to provide a full, surrounding shield. Power for the circuit is in the form of two independent 15-V dc power supplies with outputs tied to form the +15-V dc, 0-V ground, and -15-V dc (see Fig. 2).

A Wanlass "Maverick II" is presently serving this function and seems to have more than adequate reserve; a power supply of this quality is recommended.

RELATED EQUIPMENT

The Ss can be caged in Grason-Stadler soundproof boxes; however, two minor modifications are recommended: (1) An inverted "U"-shaped wood piece should be installed so there is a board across the top and down both ends. This board allows space to install the light for day-night cycles, the microphone, and any other equipment needed in the box. The day-night cycle can be set by a 24-h timer outside the box. (2) The box should be lined on the top and sides with ½-in. foam rubber to eliminate excessive sound bounce and reverberation. A standard lab rat cage (18 x 12 x 6½ in.) serves as the cage for the Ss. Pine shavings, since they do not produce unwanted signals, function well as the litter material.

Several types of cage tops are not recommended, since spurious signals result from this usage. For example, the folded sheet-metal top frequently supplied with these cages is unacceptable because unwanted signals are produced when the mice hang by their feet from the top and when they bump into the built-in food tray. A top of ¼-in. hardware cloth is better, but a few spurious signals are still possible. The most effective product for cage tops is plastic "egg crate" material frequently used in school and institutions to cover ceiling light fixtures. This material is ½ in. thick and made up of ½ x ½ in. squares. With the metal and hardware cloth tops, mice spend large amounts of time hanging from the top. No mice

Table 1
Parts List

IC 1, 2, 3, 4	μA 741
IC 5	μA 741 or μA 748
IC 6	μA 748
IC 7	9601 Fairchild
Reed Relay	Automatic Electric PD-1302-A08A
Microphone	"Realistic" #33-907
Transistor	2N3643
Zener Diode	5.1 Volts 1N5231
All other Diodes	FD 100
(All fixed Resistors are 5%)	
Power Supply	Wanlass "Maverick II" Hecon Corporation
Printout Counter	"Datatotal" Model 1140 12-column set for 4 columns of 3 digits each

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Fig. 1. Squeal detection apparatus. Schematic diagram.

were observed engaging in this behavior with plastic tops in over 5 h of observation.

Further elimination of unwanted signals can be achieved by not feeding the Ss standard lab pellets, since these can cause counts if struck against the sides of the cages. But this problem can be eliminated by feeding a semisoft dog food such as "Top-Choice." Water is made available

by using large-mouth jars with No. 10 to No. 11½ stoppers with the drinking tube installed. These jars are simply inverted on the top of the cage cover with the drinking tube extending downward.

Although noise from the exhaust fans in the Grason-Stadler boxes is not great enough to be objectionable, one modification is recommended. The fans should be mounted to the box

with a spacer consisting of a sandwich of Masonite, 1 in. of foam rubber, and Masonite. One side of the spacer is bolted to the box, and the fan is bolted to the other piece of Masonite. The foam rubber isolates the fan from the box and limits mechanical transmission of noise. An air passage should be cut into the center of the foam. In our research, further reduction of fan noise was attempted by reducing the fan speed by an electronic motor speed controller. Auditory noise was reduced, but electronic noise was increased slightly; therefore, it is recommended that the motors be run at full speed.

A simple monitoring system can be added by mounting an inexpensive microphone or a small speaker inside the box. This pick-up device is of low output, so some preamplification is necessary. Figure 3 shows a simple preamplifier circuit which functions well in the system (Marston, 1970). The output of the preamp feeds into a Heathkit AA-18 amplifier which drives the monitor speaker. This system of monitoring is simple, inexpensive, and does not impinge upon the detector circuit.

Fig. 2. Diagram of power supply connections.

The accumulation of data is handled nicely by having the reed switch closures of the detectors operate the counters in a printout counter (POC). Presently, a 12-column Datatotal (Model 1140) POC is set up for 4-3 digit columns to accumulate data from four boxes simultaneously. The printing of data can be handled in several ways. If short intervals are desired, electronic timers, or clock-type timers, can be used to signal the print function of the POC; if longer intervals are needed, a slow-moving motor (i.e., 1 rph) can be used to operate a microswitch via a cam. This switch closure operates a pulse former which gives the print signal. Since, in the course of several days of observation, the data would be printed quite often, a check on the printout and reset function is recommended (see Morgret, 1971, for details).

CHECK-OUT OF THE SYSTEM

The preliminary settings were as follows: center frequency = 4,000 Hz with the bandwidth $\approx \pm 200$ Hz. A tape recording was made at 7½ ips through the microphone in the box, and a standard tape of a given number of squeals was made. This tape was then played through the system and sensitivity was adjusted until the correct score was counted. Following this setting, a pure-tone signal was fed into the boxes from a General Radio Beat Frequency Audio Generator (Type 1304-B) through a speaker placed in the same location in each of the boxes and the threshold voltage was measured. The triggering voltage ranged from .6 to 1.1 V, this range reflecting differences in the accumulated tolerances of the individual components in each system. A second measurement of threshold voltages was taken after 70 days running, and the mean voltage change was .077 V, reflecting stable performance overtime.

A search for false positive counts

Fig. 3. Schematic of preamplifier for monitor system.

was undertaken by allowing the system to run without a S for 617 h. During this time, 26 counts were recorded for a total of .042 counts per hour. Local power failures probably account for some of these. When the system is in actual service, there are so many S response counts per hour that the contribution of this type of error is exceedingly small.

The setting of $\approx \pm 200$ Hz around the center frequency of 4,000 Hz may seem narrow; however, the bandwidth was calculated in terms of ± 3 dB, and detection of signals above and below these frequencies is possible. However, the probability of detection decreases as the frequency of the signal deviates from the bandpass frequencies. Detection, therefore, is not strictly limited to the bandpass but extends to some degree on either side. As a further check on the correctness of the setting, 30 mature male Swiss Webster mice were used as an empirical check. Each mouse was introduced into the experimental chamber, and a squeal was elicited by a tail pinch. All Ss operated the mechanism.

Since the system was designed for mice, the above adjustment settings would serve as a close approximation

of the final settings; however, the user should take a sample from the Ss to be measured and check the system under conditions of actual data collection. Only small adjustments would be required in this instance. For use with rats, larger adjustments would probably be needed.

REFERENCES

- HALL, C. S. Temperament: A survey of animal studies. *Psychological Bulletin*, 1941, 38, 909-943.
- KAHN, M. W. The effect of severe defeat at various age levels on the aggressive behavior of mice. *Journal of Genetic Psychology*, 1951, 79, 117-130.
- MARSTON, R. M. Experimenters ... 30 IC circuits you can use. *Radio-Electronics*, February 1970.
- MORGRET, M. K. A procedure for constant monitor of printout counter reset function. *Journal of the Experimental Analysis of Behavior*, 1971, 16, 176.
- SCOTT, J. P., & FREDERICSON, E. The causes of fighting in mice and rats. *Physiological Zoology*, 1951, 24, 273-309.
- THOR, D. H., & HOATS, D. L. Morphine-amphetamine-induced fighting and interim socialization. *Psychonomic Science*, 1970, 20, 156-158.
- THOR, D. H., HOATS, D. L., & THOR, C. J. Morphine induced fighting and prior social experience. *Psychonomic Science*, 1970, 18, 137-139.