*INDUCED ELECTRIC CURRENT FLOW IN THE PIGEON
AS A FUNCTION OF IMPRESSED VOLTAGE AND
PULSE FREQUENCY¹*

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Measurements are reported for four White Carneaux pigeons (10-13 yr old) of induced current flow, through chronic pubis electrode implants, as a function of the two shock parameters, intensity and pulse frequency.

METHOD

Electrodes of #20 gauge gold-on-copper wire were tied around the pubis bones of the birds (Azrin, 1959). Two birds (#19 and #21) were prepared 15 months before the data were obtained, and the other two (#5 and #11) were prepared 3 hr prior to the first set of measurements, to determine the effects, if any, of the formation of scar tissue or other by-products of chronic implants.

A monitored constant-voltage transformer supplied 60 cycle AC across a precision resistance in series with the bird, and the voltage drop across the resistor was read from a calibrated oscilloscope. The voltage drop across the bird and the current flow were calculated using Ohm's law. At each voltage, the bird was exposed to a train of ten, 60-millisecond duration pulses at a rate of 1 per sec, followed by approximately a 90-sec "rest" before the next voltage test level was applied. Voltage across the bird was varied in 15 approximately equal steps from 4 volts to 80 volts peak-to-peak. Each bird was exposed to an ascending (low to high) and a descending series of the voltages used, in that order, and following each series a redetermination of the initial value in that series was made, pauses between series and redeterminations being again approximately 90 sec long.

Forty-eight hours after a bird had been exposed to the voltage series, measurements of current flow were taken as a function of

voltage pulse frequency. During the pulse frequency measurements, the total voltage (across the resistor plus the bird) was held constant at 50 volts peak-to-peak. Pulse frequency was varied in 10% steps from 1 pulse per 3.0 sec to 1 pulse per 0.3 sec. At each pulse frequency, a train of 10 square pulses of the 60 cycle AC was given. Intervals of approximately 90 sec separated determinations. An ascending (slow to fast) and a descending series were used, and the initial values were redetermined at the end of each series.

Seventy-two hours after the pulse frequency measurements were made, a new series of voltage measurements was begun. During this series, the voltage was impressed continuously, without "rests" between voltage test levels, and varied in approximately 7-volt steps from 5 to 35 volts peak-to-peak across the bird.

RESULTS

The relationship between the voltage across and the current flow through the birds for the range of impressed voltages used is closely linear. Regression equations² fitted to the data (*I* in amps) by the method of least squares are, for Bird 5: $I = 0.0017V + 0.0077$; for Bird 11: $I = 0.0023V + 0.0029$; for Bird 19: $I = 0.0020V + 0.0050$; for Bird 21: $I = 0.0023V + 0.0062$. There appeared a faint suggestion of a plateau in the region of 90-110 volts which may or may not be significant. Differences between fresh and old electrode implants seem negligible.

Variations in pulse frequency, with voltage fixed, do not seem to affect current flow over the frequency range used here, whether with

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²The intercept constants of these equations indicate, not that there is any current flow at $V = 0$, but that below 4 volts across the bird there is a non-linear drop to zero that departs from the relations expressed by these equations.

fresh or old implants. The data were so consistent for all frequencies that they can be summarized as follows—Bird 5: Mean voltage across bird (V) = 33.31, σ = 0.71, and the mean current (I) = 166.6 milliamps; Bird 11: V = 37.82, σ = 1.22, and I = 189.1 ma; Bird 19: V = 35.32, σ = 0.57, and I = 176.6 ma; Bird 21: V = 34.22, σ = 0.61, and I = 171.1 ma. The low variabilities are in accord with Azrin's (1960) statement regarding smaller current flows.

The continuous inputs, without timed "rests" separating voltage steps, also produce no significant departure from the equations presented. Nevertheless, the continuous inputs were integrated physiologically in some way, because they produced symptoms severe enough to halt the series after the first few voltages tested lest the bird be killed or permanently damaged. No differences in

severity between fresh and old implants were apparent.

The distress reactions of the birds were observed under the several experimental conditions. In general, amount of distress rose with the voltages. During the pulse frequency test series, distress seemed somewhat more marked at the intermediate and slower frequencies. As noted, however, most distress was exhibited in the continuous input tests, indicating that "rests" between determinations have some effect in helping to cope with the deleterious effects of shock.

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