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BRIEF COMMUNICATION

Apparatus for Quantitative Evaluation of Visually Guided Pecking in the Pigeon

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MORELLI, M., D. MUSUMECI AND L. NICOTRA. *Apparatus for quantitative evaluation of visually guided pecking in the pigeon.* PHARMAC. BIOCHEM. BEHAV. 3(5) 919–922, 1975. – An apparatus using a phase-locked loop is described which allows automated, differential counts of correct and incorrectly oriented pecks, elicited by apomorphine in the pigeon. This apparatus provides a unique and precise means for the study of this characteristic, visually guided behavior.

Apomorphine Pecking Pigeon Contrast discrimination Phase lock

IT has long been known that apomorphine, which exerts an emetic effect in other species, elicits pecking activity in the pigeon [4].

This effect has been attributed either to feeding hallucinations induced by the drug [8], or to pharmacological stimulation of the motor centers subserving pecking movements [2]. Recently, evidence has been provided in favor of a third interpretation, namely that apomorphine pecking is the result of pharmacological activation of specific hypothalamic motivational centers for feeding [3]. According to this interpretation, apomorphine pecking should be considered analogous in its neural mechanism to spontaneous pecking which an animal displays as a part of its instinctive feeding behavior.

In the course of our study on the mechanism of apomorphine pecking, it soon became apparent that this phenomenon is absent when the animal is placed in a uniform, white environment. In this situation only occasional pecks may be delivered by the bird, and only at those points which make some contrast against the background, i.e. its own feet or claws, or the edges of its own shadow. However, when a few black spots are placed on the floor, the animal dramatically increases its pecking rate and clearly aims the pecks at the black spots.

Thus, contrast has a dual effect on apomorphine pecking in the sense that it acts both as an eliciting stimulus and as a goal object. Clearly, then, the overall count of pecks per time unit [9] gives an incomplete quantitative description of apomorphine pecking and of its changes; differential counts of the pecks aimed at the black spots (correct pecks) and of those delivered on the white background (wrong pecks) yield a far more complete picture, in that it allows the pharmacologically elicited motivation and the accuracy of the pecking movement to be evaluated separately.

METHOD

Procedure

Before starting each session a small, light, capacitive transducer-probe encapsulated with epoxy or a silicon rubber compound is glued on the pigeon's beak (Fig. 1). The wires to the recording apparatus are sutured to the scalp. The claws are wrapped with white tape to decrease the contrast between them and background. The pigeon becomes habituated to this apparatus in a short time. After an adaptation period of about 15 min in the experimental chamber (an aluminium kettle 47 X 45 cm), apomorphine is injected; the testing session lasts about 1 hr, which is the approximate duration of the behavioral effects induced by apomorphine. In order to obtain uniform illumination the kettle is rounded off at the corners, painted internally with white paint and illuminated with a slide projector powered by a stabilized AC voltage. A frosted glass sheet diffuses the light beam and neutral density filters control the intensity (Fig. 2).

On the bottom of the aluminium kettle there are 19 circular special areas. In the center of each area small transfer-type black spots are placed. Pecks which are

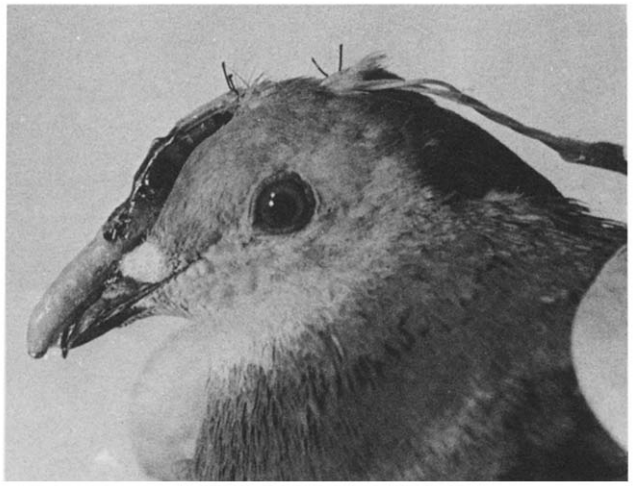

FIG. 1. Transducer probe on pigeon beak.

directed in the vicinity of the black spots are counted as correct.

Apparatus

The capacitance between the aluminium kettle and the sensitive surface of the probe changes from a few tenths of a picofarad to 4–5 pF when the pigeon pecks the insulated white surface and to 7–8 pF when it pecks on or close to the black spots. The necessary miniaturization of the probe attached to the beak and the fineness of the wires prevent the use of most of the circuits normally used to detect such small changes in capacity.

A very light probe with few components and only 3 connecting wires is obtained if the capacity changes control the frequency of an unijunction transistor (UJT) relaxation-oscillator [6,7].

A phase-locked loop will demodulate the amplified output of the probe, since during lock, the average DC level of the phase comparator output signal is directly proportional to the frequency of the input [5].

Since the maximum operating frequency of the phase-locked loop (type NE 560B) is about 500 kHz, the probe frequency is divided by 10. The output of the phase-locked loop is amplified, displayed on an ammeter, filtered and fed to a level discriminator so that the black spot pulses and the white pulses are separately counted and displayed on a polygraph (Fig. 4).

Circuit Design

The UJT relaxation oscillator has good stability relative to power supply and temperature variations [5,7]. It is necessary to point out that a small fixed capacitor of about 2 pF, mounted in the form of a short piece of shielded cable in parallel to the variable capacitance (emitter of UJT), insures the starting of the oscillator and minimizes the capacity variations, when the pigeon does not peck, at the expense of sensitivity. The free running VCO (voltage

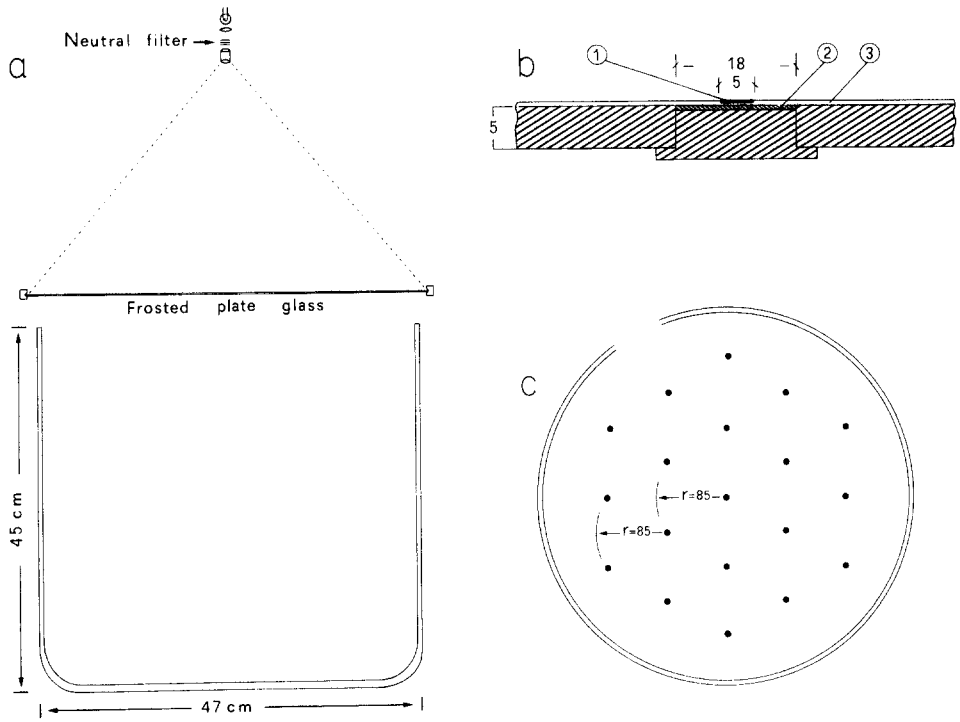

FIG. 2. (a) Cross section of the aluminium kettle and illumination system; (b) cross section of the sensitive areas. (1) transfer type black spot. (2) dielectric layer. (3) white paint; (c) the arrangement of black spots.

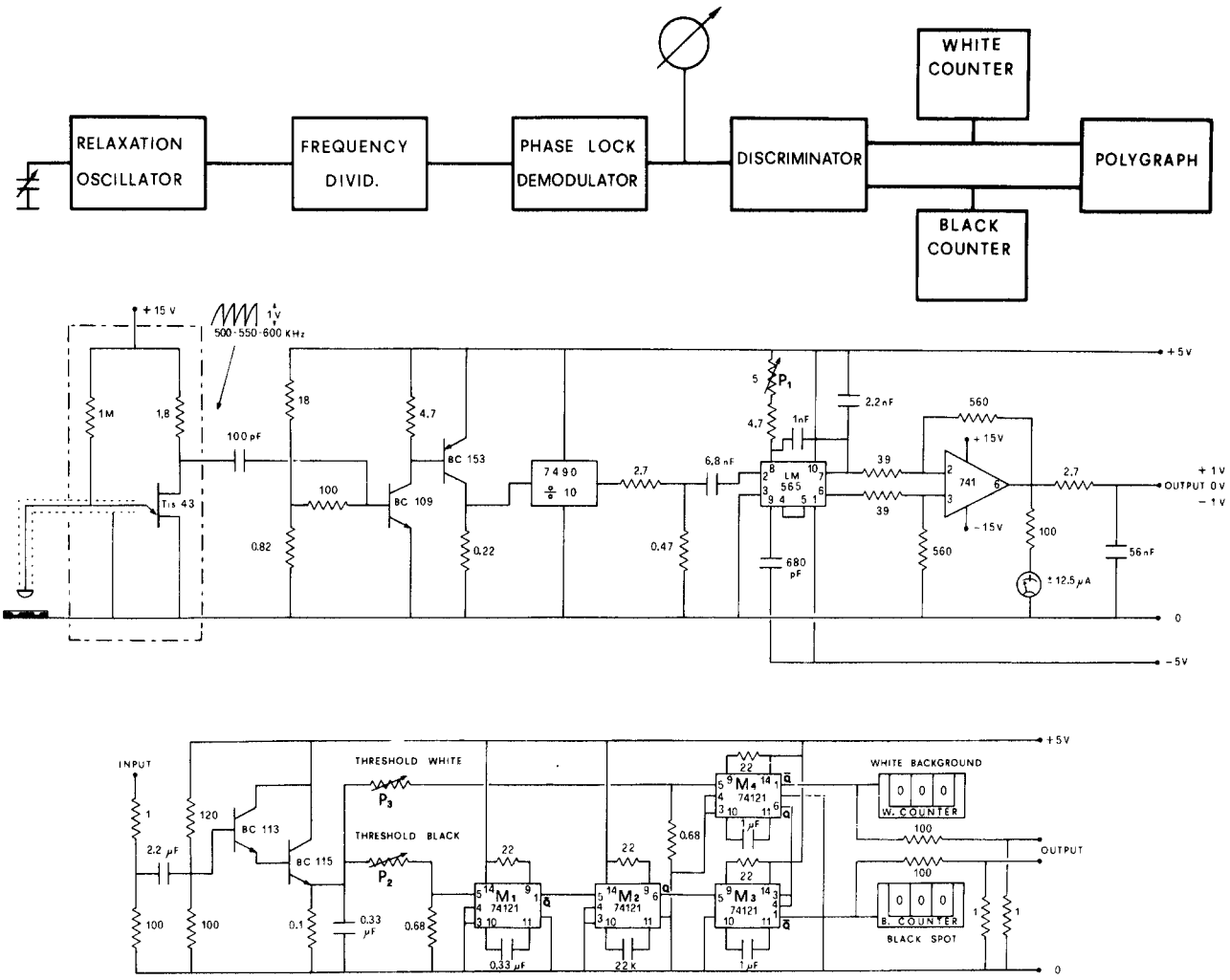

FIG. 3. Electronic circuit. Resistor value in kΩ if not specified.

controlled oscillator) of the integrated circuit (IC) phase-locked loop is controlled by the potentiometer P_1 (Fig. 3) in a range of ± 20 percent of the frequency (55 kHz).

It is possible to easily set up P_1 to lock the input frequency f_0 about the middle of the lock range. For best operation the free running VCO frequency should be adjusted so that the output voltage swings equally for the two input frequencies of 50 kHz and 60 kHz, to both sides of the reference voltage at pin 6 of LM565 [5]. Finally the output of IC phase-lock is differentially amplified by a 741 IC to minimize the drift.

The discrimination between the black spot pulses and the white pulses is obtained by using the 74121 IC monostable multivibrators M_1, M_2 M_3 and M_4. The Schmitt trigger input of the 74121 has an excellent noise immunity and allows jitter free triggering from inputs with transition times as slow as 1 $Vsec^{-1}$.

When the input pulse crosses only the lower threshold a 20 msec negative going pulse $\bar{Q}$ of M_3 is triggered via M_1, M_2 and M_3 and fed to the B counter and to a polygraph channel.

When the input pulse crosses both thresholds in 5 msec or less, the positive output pulse Q of M_4 will inhibit M_3 and only the negative output $\bar{Q}$ of M_4 is fed to the W counter and to the other differential input of the polygraphic channel. Figure 4 shows the polygraph display.

The system requires that the duration of the one shot pulse of M_4 be equal or longer than the sum of the durations of the M_1 and M_2 pulses. The threshold voltages are calibrated by setting the potentiometers P_2 and P_3.

The device has been used for more than a year with excellent results as to reliability, ease of calibration and stability.

RESULTS

Figure 4 is an example of the records obtained in standard experimental conditions.

In lack of contrast, *i.e.* uniform background, only occasional pecks are seen in Fig. 4A. The motivated pecks with 30 Cd m^{-2} of luminance are seen in Fig. 4B, the number of these being significantly larger than that of wrong pecks. Figure 4C represents the results obtained with 0.03 Cd m^{-2} of luminance whereby an increase in occasional pecks and a decrease in correct pecks are observed.

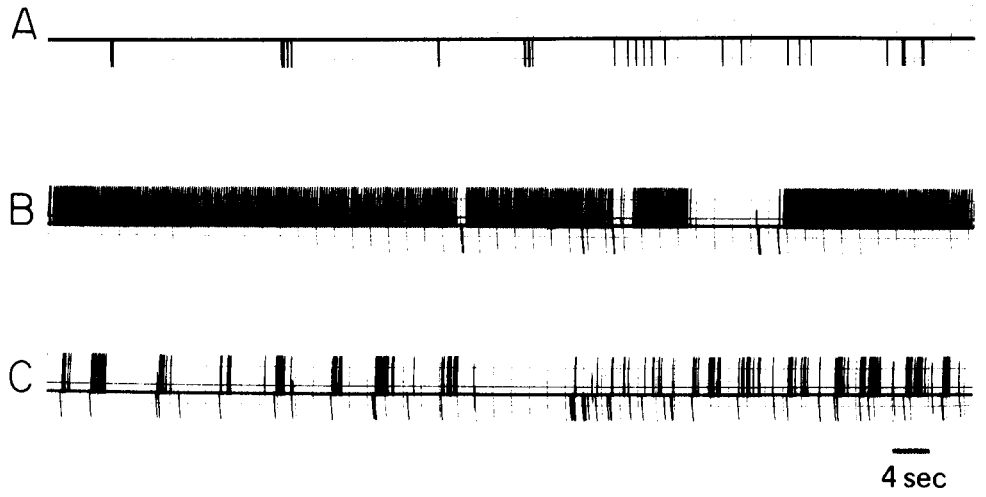

FIG. 4. Counts of correct or wrong pecks: (A) Uniform background (white); (B) Black spots on the floor 30 Cd/m^{-2}; (C) Black spots on the floor 0.03 Cd/m^{-2}.

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