AUTOMATIC PHOTO-ELECTRIC DEVICE FOR THE STUDY OF CONDITIONED REFLEXES IN SMALL ANIMALS

E. P. Kornil'ev and A. P. Korolebskii

Institute of Biological Physics (Director – Corresponding Member AN SSSR
G. N. Frank, AN SSSR, Moscow
(Presented by Active Member AMN SSSR, E. V. Parin)
Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 56, No. 7,
pp. 113-116, July, 1963
Original article submitted June 11, 1962

Many descriptions have been given of devices for the elaboration of conditioned reflexes in small laboratory animals, and in certain cases provision was made for conducting the experiment automatically or for recording the different quantities involved in the response [2-6].

While not disputing the advantages of one method or another we must point out that most arrangements incorporating automatic devices are designed in such a way as to produce conditions which reduce the motility of the animal. However, in many cases, it is important to investigate the conditioned reflex responses under conditions in which the animals are allowed free movement. It is especially important in the case of mice where the principal index of the conditioned reflex until now has been the distance run. Although they satisfy these requirements, the arrangements of Ganike and Federov are large and complex.

We have produced an improved form of the arrangement of Fadeeva and Izergima for investigating the conditioned-reflex run of an animal towards a point of reinforcement, and have developed a system for the automatic control and recording of the quantities involved in the conditioned motor response.

The apparatus consists of a chamber on the back wall of which are fixed nests (boxes) for mice and rats. There is free entry into the chamber from the nests through holes of slightly greater diameter than the mouse or rat. In the chamber there are also two inclined gutters for the animals connecting the exists from the nests with the point at which reinforcement is given in the form of drink or food. Because we used drink as reinforcement we will describe the relevant method.

Drink as reinforcement was supplied by a modified microburette whose end was brought out into the chamber. The animal had access to the drink through a small opening (whose diameter was slightly greater than the head of a large mouse or rat) cut in a plate of perspex.

Observations were made by a system of mirrors and with an automatic electronic system. The chamber was closed above by glass. Light stimulii were arranged in the nests and at the point where the liquid was given. Sound stimulation was supplied through a loud speaker fixed to the floor of the chamber.

Around the sides of the gutters (Fig. 1) along which the animals ran from the nests to obtain drink, resistance-type photo-electric cells were fixed at four control points and the system was illuminated by lamps and condensing lenses. The control points were arranged as follows:

1. Directly at the exit from the nest;

2. At intermediate points along the length of the gutter; and

3. Directly by the drink.

The photocells were arranged so that when the animal passed a control point the beam illuminating the photocell was inevitably interrupted.

This arrangement of control points enabled the following components of the conditioned response to be determined; latent period, strength of the conditioned reaction, strength of the actual drinking response, inter-signal running to the drink.

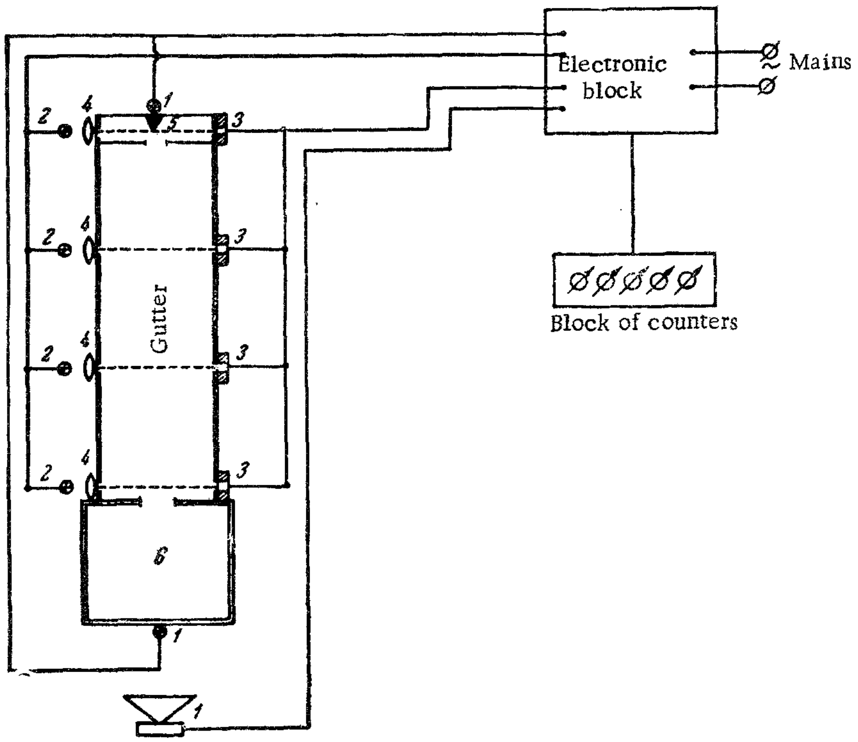

Fig. 1. Diagram of the arrangement. 1) Sources of stimulation; 2) lamps; 3) resistance-type photocells; 4) condensing lenses; 5) drinking point; 6) nest.

Intermediate control points play a supplementary part and serve to indicate changes in the rate of movement along different portions of the pathway.

Measurement of the different quantities associated with the conditioned response, the arrangement in time of the stimuli and their presentation, and certain other features were made possible by an automatic electronic system whose salient points are as follows:

The system allows stimuli set to last for anytime between one and thirty seconds to be presented, and give two separate luminous periods which can be adjusted to last for between one and 20 seconds; the accuracy is ± 0.02 seconds. Time can also be measured with the same accuracy between application of the stimulus and the passage of the animal past the first control point (latent period of the response); the time can also be measured between the successive passages past the three other control points (strength of conditioned response).

When the animals pass the last control point the system returns to the initial condition and automatically records the time spent at the last control point (strength of natural drinking response expressed as time of drinking effort).

If the animal did not emerge at the signal and if he did not pass all the control points during the presentation of the stimulus the system returns to the original condition.

If it approaches the last control point after a delay (five seconds in our experiments on mice) the system automatically prolongs the action of the stimulus by an amount equal to the delay time. Therefore at the time at which it is supplied the amount of fluid used for reinforcement always remains constant.

The system supplies a luminous indication of the moment of reinforcement when the animal emerges normally after a delay. It makes possible to record the number of runs towards the drink in the intervals between signals.

The chief features of the electronic system are as follows. Stimulus is applied by a switch P_1 (Fig. 2), which operates relays R_1 and R_2, at the same time switching in the stimulus, the automatic system, the time relay and the first electromagnetic counter.

When the animal passes the first control point it intercepts the beam incident on the first photocell FS_1 so causing ignition of the thyratron T_7 and switching on relay R_7; then counter C_1 is then disconnected, and C_2 is switched on.

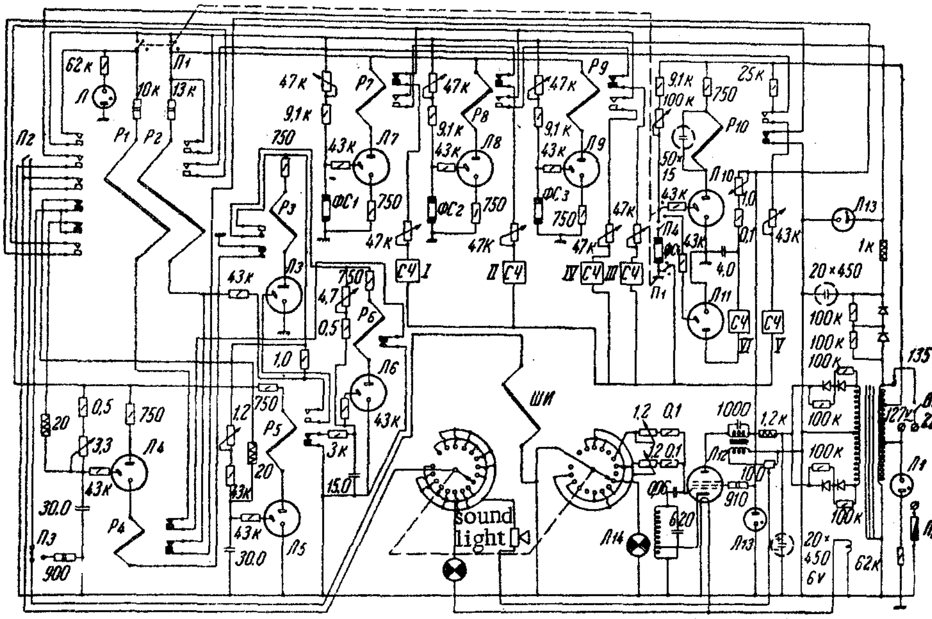

Fig. 2. Circuit of photo-electronic automatic device. Variable resistance photocell FSK-1; thyratrons MTKh-90; Counters type MÉS-54.

Some of the following Russian abbreviations may be found in the figure: Л = tube, Д = diode, Тр = transformer, Др or др = choke, Вк = switch, в = V, М = MΩ, к = kΩ, мк = μF or μH, п = pF or pH, and н = nF or nH.

The passage of the animal passed the subsequent control points causes a corresponding switching on and off of the remaining counters. In this way a time record is made of the run along the section between control points.

The interception by the animal of the last ray when it attempts to drink causes counter C_4 to be disconnected, and brings into circuit C_5 which operates during the whole time the animal is at the control point number four. This same action causes all other counters except C_5 to be switched off.

The duration of the stimulus is controlled by the timing relay consisting of thyratrons T_4, T_5, and T_6.

Ignition of thyratron T_5 through the predetermined delay time gives the experimenter a signal indicating that reinforcement must be supplied if the animal has already arrived at control point four. If it waited on the way towards this point reinforcement is supplied at the moment that T_3 ignites.

If the animal did not emerge in response to the conditioned signal or if it failed to arrive at control point number four during the action of the stimulus, the timing relay on T_4 switches off the stimulus and returns the system to the initial condition.

If the animal delays at control point four, the timing relay on taratron T_4 is disconnected and its function is taken over by the timing relay based on T_6 which switches the system off after a certain time interval, returning it to its initial condition.

To record runs made between signals a use is made of the photocell at control point four which then connects thyratron T_{11} and the number of runs is recorded by counter C_6.

The sound stimulus is made through a loud speaker connected to the oscillator circuit of tube T_{12}.

The conditioned stimuli are switched on automatically by the selector switch S-17 which is short-circuited by tumbler switch T_3 when a separate conditioned reflex is being elaborated.

The power supply is from the alternating current mains through two stabilized rectifiers. In the construction of the electronic circuit special attention has been paid to the sound-insulation of the electromagnetic relays and counters.

The principal features of the conditioned reflex response to be measured, and the time of action of the stimulus and its reinforcement could be recorded graphically by replacement of the counter by a writing device.

In our arrangement the experimenter himself switched on a particular cycle representing a set of conditioned stimuli. We deliberately refrained from presenting these stimuli as part of the complete program because from reports and from our own experiments it can be seen that in conditioned reflex work with small laboratory animals it is difficult to submit the highly labile central nervous system to a rigidly programmed rhythm of work. The necessity for interference by the experimenter occurs particularly often in experiments on animals which have undergone pathological changes.

SUMMARY

We describe a unit having an automatic photo-electric device for investigating the conditioned motor responses in small animals. It was made for investigation of an animal running to the site of reinforcement. In collects sufficiently accurate analyses of the times of the main events associated with free movements of the animals in the normal or pathological conditions. The instrument may find application in physiological laboraties for the study of higher nervous activity.

LITERATURE CITED

1. L. M. Korablev, Cold Cathode Tubes [Moscow] (1961).
2. L. I. Kotlyarevskii, Zh. vyssh nervn. deyat., No. 5, (1951) p. 753.
3. L. I. Kotlyarevskii, Transactions of the Institute of Higher Nervous Activity AN SSSR. Series: Pathophysiology. Moscow, Vol. 3, (1957) p. 23.
4. N. M. Papyshev, Byull. Éksper. Biol. No. 3, (1957) p. 118.
5. M. Yu. Ul'yanov and N. M. Kobyakov, Zh. vyssh nervn. deyat., No. 6, (1961) p. 1134.
6. V. K. Fedorov, Zh. vyssh nervn deyat., No. 5, (1951) p. 744.

All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.