

AN AUTOMATIC RECORDING DEVICE FOR USE IN ANIMAL PSYCHOLOGY¹

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There are many experiments in animal psychology which may be done with a great conservation of the time and energy of the experimenter if a reliable automatic recording device is used. The use of such a device may have also a further value in that there is no danger of the transmission of unintentional cues from the experimenter to the animal. A still further advantage lies in the fact that there is a lessened danger of making unconscious prejudicial errors by the experimenter.

These considerations, therefore, justify the search for a reliable, simple, and inexpensive recording device which is capable of use in many experiments with animals in which quantitative data are the measure of the subjects' performance.

The purpose of this paper is to describe the apparatus which we are now using in this laboratory. Two other pieces of apparatus for a similar purpose have been described in the literature, one by Tolman and Jeffress (1) and another by Tolman, Tryon, and Jeffress (2).

For purposes of exposition, we will describe the apparatus under three headings: 1, the maze which is used for rats with its accessory apparatus; 2, the recording device; and 3, the automatic turntables which allow the entrance of one animal at a time into the maze and its removal after traversing the maze before another enters.

¹ The author is indebted to the University of Minnesota Graduate School from which he received the financial aid necessary to carry on the experimentation upon and the construction of this apparatus. He is also greatly indebted to Dr. Starke R. Hathaway for innumerable suggestions with reference to the mechanical and electrical problems encountered in the design and construction of the apparatus, and to Dr. Lewis E. Drake for suggestions concerning the particular pattern of maze which is at present used in connection with the recorder.

We will not endeavor to give such constructional details as would be necessary for an exact duplication of the apparatus. Such an endeavor would require too much space. However, the author will be glad to supply such details to anyone who may desire to make an exact duplication of the apparatus.

1. THE MAZE AND ACCESSORY APPARATUS

The maze which is now being used is not an essential part of the recording apparatus as one virtue of the latter apparatus is that it may be used with any maze with a few simple modifications. However, since this maze embodies certain novel features, it is thought worthwhile to describe it.

This maze is composed of units all of which are identical in design. One unit and part of the preceding unit is shown in figure 1a. This diagram shows the unit and part with the opaque cover removed. The cover being opaque makes the maze light-proof. The rat moves in the direction of the arrow which is seen at the left of the diagram and within the portion of the maze which belongs to the preceding unit. At the point *A* he may go in either of two directions, i.e., a right angle turn either to the right or to the left with reference to his body. Depending upon the pattern used, he will find either door *B* or *B*₁ locked. Since all units (12 in number) of the maze are identical except for the position of the locked door, the animal must learn to make the correct turn at point *A* in the successive units in order to avoid the locked door. Should he fail to do so then he must return to point *A* and continue on around and through the unlocked door. In other words, in each unit the path leading to the locked doors constitutes the blind alley in that unit. Since the experimenter can lock the door on either the right or left in each unit the number of patterns possible in the total maze is determined by the permutations of 12.

All the doors in the maze are identical in construction. They are always closed except when opened by an animal. They may be locked or unlocked by an arrangement which is not shown, but which may be operated by the experimenter from outside the maze.

A cross section through one of the doors is shown in figure 1b.

The animal enters the door in the direction of the arrow. His weight depresses the bottom portion of the door. This tends to raise the upper portion by means of the lever arrangement as indicated. He may also push up on the upper portion. These portions are made of galvanized iron so that they are relatively light and furthermore, they tend to balance each other, although the top door is slightly heavier in order to make the door close after the animal. The point of junction of the two parts when the door is closed is hidden by a short partition at the exit of the door. This arrangement may seem rather complicated but all simpler mechanisms which we have tried have had the fault that the rat could open them backwards. The locking arrangement is so localized that the animal cannot see whether the door is locked or unlocked.

Running under the maze throughout its entire length is a tunnel, the open end of which is seen at *C* in figure 1a. This tunnel is used for the preliminary training of the animals before they are allowed to run in the maze. The animals may be shunted in or out of any unit or series of units by means of a door in the floor of each unit. Two of these doors are shown in figure 1a at *D* and *D*₁. Each door is so arranged that it can occupy either of three positions: 1, A horizontal position as shown in the diagram in which case it forms part of the floor of the maze; 2, the end towards the entrance of the maze at the level of the floor of the tunnel and the end towards the exit of the maze at the level of the floor of the maze; 3, the end towards the entrance of the maze at the level of the floor of the maze and the exit end at the level of floor of the tunnel. If the door is in the first position the rat cannot change the level upon which he is running which may be at either the level of the tunnel or that of the maze. In the second position the animal must change from the tunnel to the maze and, if in the third, from the maze to the tunnel. The position of each of these doors may be varied by the experimenter from a position outside the maze by means of a simple arrangement of levers which is not shown in the diagram.

There still remains one other point to be described in the maze itself. This is a brightness discrimination attachment. One part

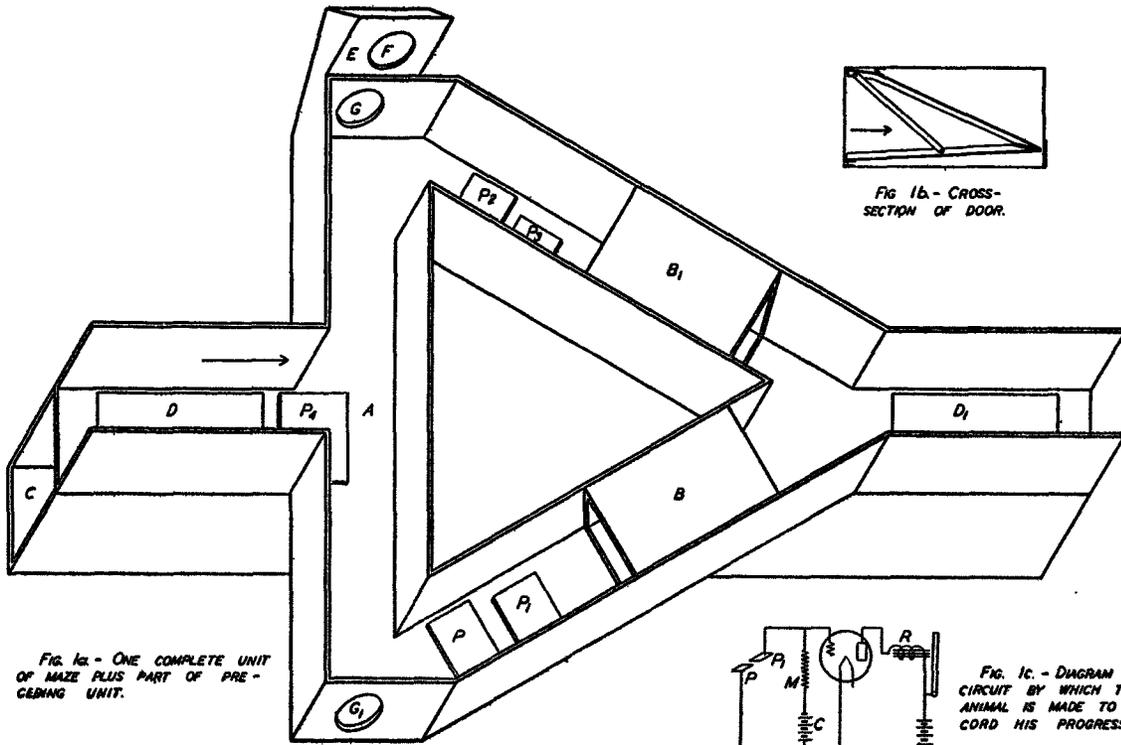


FIG. 1a. - ONE COMPLETE UNIT OF MAZE PLUS PART OF PRE-CEILING UNIT.

FIG. 1b. - CROSS-SECTION OF DOOR.

FIG. 1c. - DIAGRAM OF CIRCUIT BY WHICH THE ANIMAL IS MADE TO RECORD HIS PROGRESS.

of this attachment is shown at *E* in figure 1a. It is composed of a box which projects above the top of the maze. Inside the box are two mirrors arranged at an angle such that they will reflect light from a bulb hung in front of opening *F* into opening *G* and thus into the maze. Opening *G* is covered with glass in order to diffuse the light and prevent the rats from entering it. A corresponding arrangement is on the opposite side of the unit of which only the opening *G*₁, into the maze is shown in order not to complicate the drawing. The bulb is hung from a bar which is supported on one end by the top of box *E* and on the other end by the top of the corresponding box on the opposite side. The bulb can be slid along this bar. It will be seen that the relative intensity of the light entering the maze through *G* and *G*₁ will depend upon how much off-center the bulb is along the bar which supports it. If the problem is to teach the animal to react positively to the brighter side the door on the bright side is locked (*B* or *B*₁ as the case may be). Since all 12 units of the maze are identical in construction then in passing through the apparatus the animal may be forced to make twelve discriminations in going from the beginning to the end of the apparatus. Although we do not have them in the present apparatus, grills may be placed on the floor of the maze on either side of point *A* so that the animal be given punishment for an incorrect reaction. The recording apparatus (described in the next section) will work in the same way whether the apparatus is used as a maze or as a brightness discrimination apparatus.

2. THE RECORDING DEVICE

A schematic drawing illustrating the principle used in the recording device is shown in figure 1c. Reference to this diagram will show that radio tubes are used. Although only one tube is shown in reality five are used in the recorder and a sixth one controls the tables (described in section 3). All tubes are of -45 type and are wired in parallel so far as the sources of power are concerned. The principle of operation is as follows: when the conditions are as shown in the diagram the potential (in our apparatus, 90 volts) of the *C*-battery is impressed upon the grid

through the resistor, M , the value of which is 20 megohms. This prevents the flow of current in the plate circuit with the result that the relay, R , remains open. However, if the gap between plates, P and P_1 , is closed by some object which is a reasonably good conductor of electricity, the potential upon the grid changes in sign and this allows the current to flow in the plate circuit. This causes the relay, R , to close.

When this principle is used in connection with the maze the rat is the conductor which connects the plates, P and P_1 , together. It is obvious, therefore, that all which needs to be done is to place the plates upon the floor of the maze so that the rat will come in contact simultaneously with both as he runs (indicated by P , P_1 , P_2 , P_3 , and P_4 in figure 1a; D also acts as a plate). One set of plates is placed in the correct alley of each unit, one set in the incorrect alley, and one set in the connecting alley between units. Since only five tubes with a relay for each are used and there are 12 units in the maze it is obvious that each tube must be connected to several different places in the maze. However, since the rat cannot retrace his path once he has passed through a door, it is not necessary to have a tube for each alley in the maze. As a matter of fact, all the plates in the incorrect paths of the maze are connected to the same tube.

It will be obvious to the reader that almost any kind of a recording device may be attached to the relays. However, the writer uses a homemade device which is simple and economical. It consists of a motor driven set of rollers which slowly draws ticker tape under a typewriter ribbon. The latter moves in a direction at right angles to that of the tape. Directly above the ribbon are five metal fingers which lie in a plane perpendicular to the ticker tape and in a straight line at right angles to the direction of movement of the tape. Each metal finger is attached directly to one relay, therefore, when a relay is activated the attached finger presses upon the typewriter ribbon and thus makes a mark upon the ticker tape moving below it. The position of each mark on the tape and in relation to the other marks gives to it a significance which is quite obvious to anyone who is familiar with the set-up. If one uses a synchronous motor to move the tape then a

measurement of the rat's record will give the time consumed by the animal in traversing the maze. Also, if one desires, one may determine the time spent in each unit. The actual record of one animal is reproduced in figure 2.

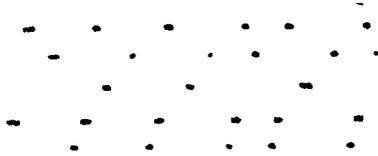


FIG. 2. THE RECORD OF ONE ANIMAL AS IT APPEARS ON THE TICKER TAPE

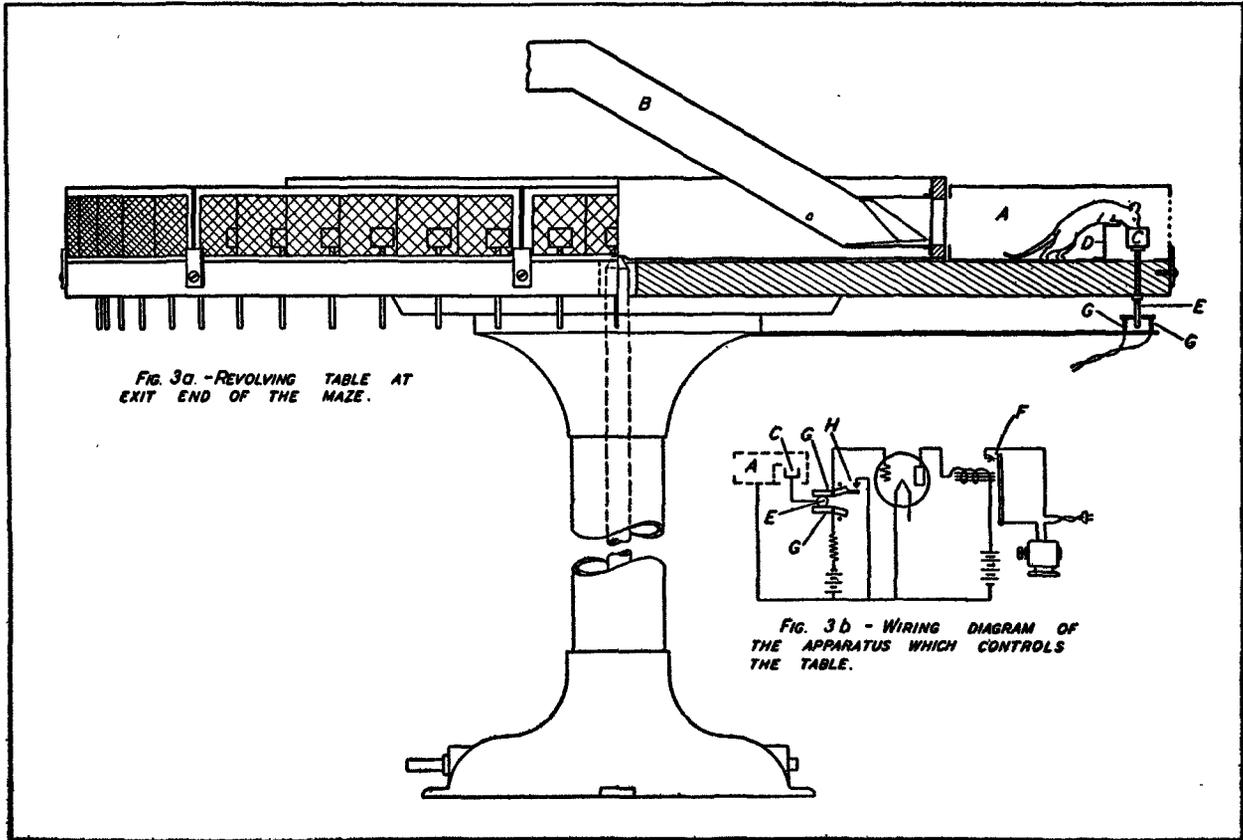
Read from left to right. Except in the first unit, two marks are made for each unit unless the animal makes an error. The pairs of dots for the even number units are at the top of the figure, and those for the odd units at the bottom. Any mark in the middle of the tape indicates an error. This rat made an error in the fourth, sixth and tenth units.

3. THE AUTOMATIC TURNTABLES

Two round revolving tables are used, one at the entrance to the maze, the other at the exit. These tables are connected together and run by a common source of power through a system of gears and a connecting link which are not shown in the diagram of the exit table, figure 3a.

The manner of operation of the table may be indicated as follows: the rat enters his individual compartment, *A*, through the inclined tunnel, *B*. In this compartment he finds food in the food cup, *C*. With his front paws resting on the metal shield, *D*, he reaches over and starts to eat the food. This causes the table to start turning.

The wiring diagram of the electrical apparatus by means of which this is accomplished is shown in figure 3b. Here, again, the rat's compartment, *A*, is shown in section with the food cup, *C*. Each food cup is supported by a metal peg, *E*, which is shown in its actual relationship in figure 3a and diagrammatically in figure 3b. A study of the wiring diagram will show that when the animal eats he changes the sign of the potential upon the grid of the tube and thus allows the current in the plate circuit to flow with the result that the relay, *F*, is closed and the motor starts.



As the motor turns the table revolves. This means that eventually the metal peg, *E*, will be withdrawn from between the two metal arms, *G*. At the instant of withdrawal the arms, *G*, swing together until a contact is made at point, *H*. The plate current, therefore, continues to flow until the next food cup with its metal peg comes in between the metal arms and, thereby, restores the negative potential to the grid. This stops the flow of current in the plate circuit and the motor stops.

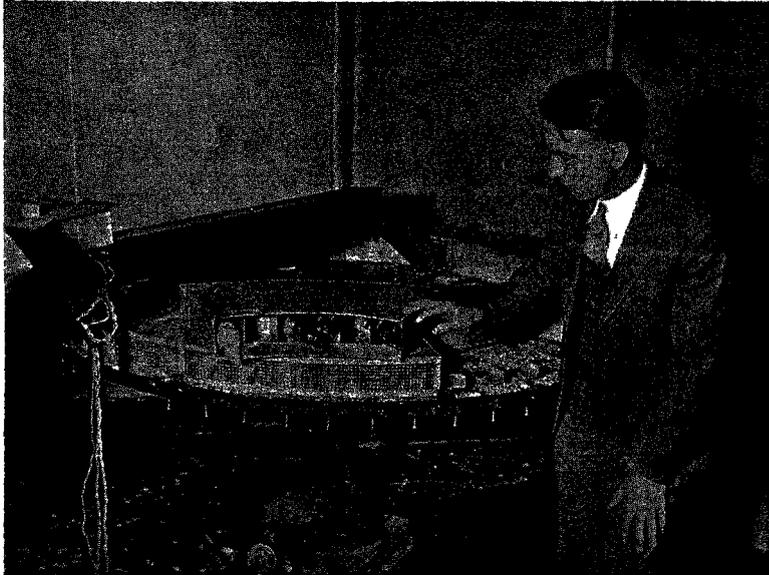


FIG. 4. A PHOTOGRAPH OF THE TABLE AT THE EXIT END OF THE MAZE

Since the table at the entrance to the maze has also turned a corresponding distance, another rat is released. When it has traversed the maze and printed its record, as described above, the whole operation is repeated. This process continues until all the animals which are on the table at the entrance end have run through the maze. When the last rat has traversed the maze the tables turn the proper distance and then all electrical connections to the maze and recording device are automatically broken. This is accomplished by a simple arrangement which is not shown.

Each table is capable of holding fifty-four individual compartments. Some of these compartments and other details of the table at the exit end are shown in the photograph, figure 4.

Once the animals are inserted into these compartments at the beginning of the training period they need not again be handled by the experimenter. Shavings are placed on the floor of the compartments and the animals live in them throughout the period of training. This means, of course, that a great deal of time is saved which would otherwise be consumed in sorting and handling the animals. Also, it means that the animals run the maze in the same order each trial.

SUMMARY

A maze for rats is described which incorporates certain novel features. An attachment to this maze enables it to be converted quickly into a multiple light-discrimination apparatus. An automatic recording device is described which may be used with any maze by putting metal plates at critical points on the floor of the maze. Automatic turntables and the method of their control are also described. These make it possible to introduce any number of animals up to fifty-four into the apparatus and then allow it to take its own course with no further supervision necessary on the part of the experimenter.

REFERENCES

- (1) TOLMAN, E. C. AND JEFFRESS, L. A.: A self-recording maze. *Jour. Comp. Psychol.*, 1925, vi, 455-463.
- (2) TOLMAN, E. C., TRYON, R. C., AND JEFFRESS, L. A.: A self-recording maze with an automatic delivery table. *Univ. Calif. Pub. in Psychol.*, 1929, iv, 99-112.