A reliable fast-operating door for small animal research*

ARMAND CARPENTIER
Regional Primate Research Center
University of Wisconsin, Madison, Wisconsin 53706

Described is a reliable and fast-operating door suitable for research with small animals. The primary operating control is a 60-rpm Hurst motor.

Experimenters sometimes need a small door, simply constructed and reliable in operation. Over the past few years we have used such a door, which utilizes basic principles and has provided dependable service. Direct drive off a 60-rpm Hurst motor provides speedy and positive action. Figure 1 provides one illustration of its use.

As shown in Fig. 1, rotation of a lever arm mounted on the motor shaft by a setscrew arrangement raises and lowers the door. One end of the lever arm has a bearing fastened to it. This bearing rides in a groove formed by two narrow strips of Plexiglas attached to the upper part of a door panel. As the lever arm rotates, the bearing moves horizontally in the groove while imparting a vertical motion to the door. This operation provides a slow-fast-slow cycle: door movement is slower as it begins to lift, speeds up, and then slows as it reaches its open position. One version of such a guillotine door performed perfectly for over 100,000 recorded trials. The door panel measures 6½ in. high x 5-3/8 in. wide, weighs 48 g, and is made of 1/16-in.-thick Plexiglas. Four models with these dimensions have been constructed. A similar version (6¼ x 5½ in.), weighing 41 g, has also performed perfectly. Two models of this door were used in Davenport, Hagquist, & Rankin (1970).

We have also constructed six side-opening doors which are operating well. The movement of the door in this case is horizontal rather than vertical. These doors are substantially heavier and are suspended on overhead ball bearings. They measure 10½ in. high x 9½ in. wide, are of 1/8-in.-thick Plexiglas, and weigh 275 g.

Figure 1 shows the four main components in the guillotine design: (1) the door panel, (2) two upright side pieces with grooves to guide the door panel's vertical movement, (3) the motor mount section, which straddles the side pieces and holds the motor, and (4) the lever arm. Plexiglas has been used for constructing the components.

Two factors influence the dimensions of these components: the size of the opening to be closed and the weight of the door panel. This panel is a piece of Plexiglas large enough to close off the opening. The larger the panel, the heavier the load on the motor which rotates the lever arm to lift the panel. With rat-sized door openings, this has presented no problems. We use 1/16-in.-thick Plexiglas stock for the door panel and a Hurst PC-DA-60 motor (115 V ac, 60 rpm, 120 inch-ounce torque at 1 rpm). A slower Hurst motor can be used to increase lifting torque at the expense of door speed.

The lever arm is fastened to the motor shaft within the U-shaped motor mount so that the bearing on the lever arm is free to travel back and forth in the door panel groove as the lever arm rotates. When the door is in the closed or open position, the lever arm is vertical, providing a certain amount of "self-locking" action.

The distance between the inner edges of the vertical, grooved door panel guides must be at least twice the distance from the motor shaft center to the farthest point on the lever arm for proper clearance when the lever arm rotates.

When designing a lever arm for an aperture of specific dimensions, it is important to note that the bottom edge of the door will move upward a distance equal to twice that from the center of the motor shaft to the outer rim of the bearing, less the vertical width of the groove in which the bearing travels. For example, if the distance between the center of the motor shaft and the edge of the bearing farther from this center is 2 in. and the groove width is 3/8 in., then the door will have a total travel range of 3-5/8 in. That is, the bottom edge of the door will open to a maximum 3-5/8 in. above the floor. The width of the groove on the door panel is slightly larger than the diameter of the bearing for a loose fit. After construction, the bottom edge of the door panel may be trimmed off slightly. This prevents

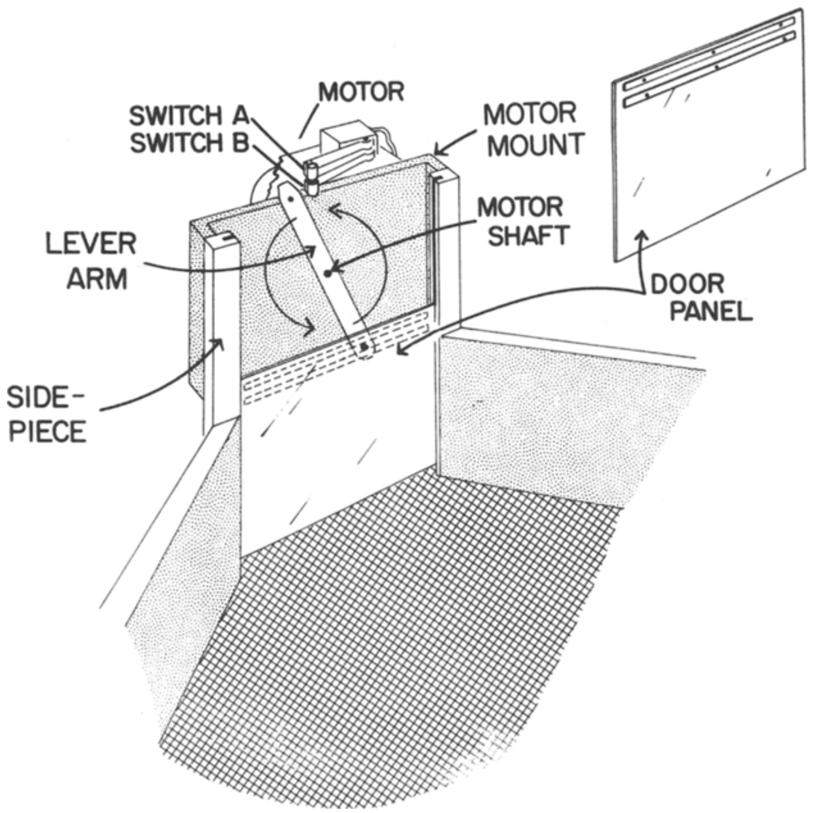
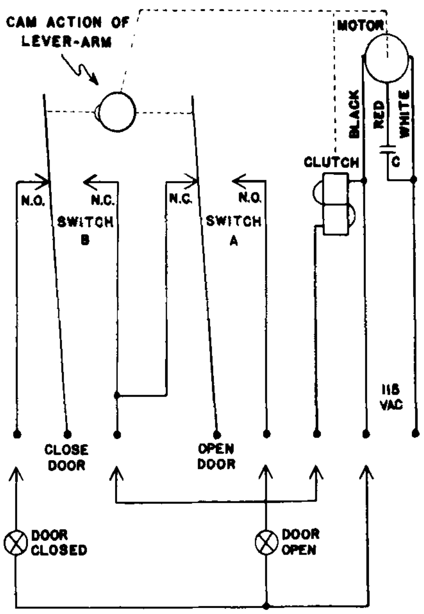


Fig. 1. Diagram showing the main components of the guillotine door.

*Supported by Grant 5-P06-RR-00167-10 from the National Institutes of Health.

†Address reprint requests to Armand Carpentier, Regional Primate Research Center, University of Wisconsin, 1223 Capitol Court, Madison, Wisconsin 53706.



closure on a rat's tail, for example.

When a door is operative, the motor is energized continuously, but the motor shaft's rotation is controlled by a clutch-brake mechanism on the motor. This mechanism provides almost instantaneous starting and stopping when the clutch is energized and deenergized. Because the PC-DA-60 operates at 60 rpm, the time required to fully open or close a door is slightly more than .5 sec.

Figure 1 shows two single-pole, double-throw switches mounted above the motor. A bolt on one end of the lever arm operates one switch (A) when the door is in the open position.

Fig. 2. Circuit diagram showing typical control circuitry for door operation. Switches A and B are shown with door in a closed position. Black, white, and red are the motor lead colors. The clutch leads are both black, and one is used in common with the motor voltage. The voltage applied to OPEN DOOR or CLOSE DOOR is opposite in polarity to the clutch common. Electrical components are as follows: Switches A and B are Robertshaw-Acro, Type 1MD1-1A-A18M; the lamps may be any 115-V ac lamps; the motor and its clutch-brake is Hurst, Type PC-DA-60; and C is a .47-microF capacitor supplied with the motor. All parts are available at Cramer Electronics, Newark Electronics, and Allied Radio.

Another bolt on the opposite end of the lever arm operates the other switch (B) when the door is in the closed position.

The schematic in Fig. 2 shows one method of controlling the door's movement electrically. Action of the lever arm on Switches A and B is represented by the irregular rotary motion of a cam which operates only one switch at a time. The switches are shown with the door in a closed position. To open, voltage is applied to the OPEN DOOR point (common of Switch A). The clutch then energizes through the normally closed contact of Switch A, and the motor shaft rotates the lever arm. A bolt on the lever arm releases Switch B common to its normally closed position. When the door reaches its open position, a bolt on the other end of the lever arm operates Switch A. This removes voltage from the clutch, door movement ends through braking action, and voltage is applied to the normally open contact of Switch A, which lights the DOOR OPEN lamp to indicate the door's position.

To close, the process is reversed. Voltage is removed from OPEN DOOR and applied to CLOSE DOOR (common of Switch B). The clutch energizes through the now normally closed contact of Switch B, the motor shaft rotates, and the lever arm bolt releases Switch A common to its normally closed position. When the door reaches its closed position, the other lever-arm bolt operates Switch B, removing voltage from the clutch and applying it to the DOOR CLOSED lamp.

Control voltage for operating a door may be alternated automatically between OPEN DOOR and CLOSE DOOR through programmed relay operation or may be switched manually with single-pole, double-throw contacts.

Other methods of controlling the door's movement can be designed, utilizing photocells or reed switches and magnets in place of Switches A and B.

REFERENCE

DAVENPORT, J. W., HAGQUIST, W. W., & RANKIN, G. R. The symmetrical maze. An automated closed-field test series for rats. Behavior Research Methods & Instrumentation, 1970, 2, 112-118.