One set of 32-bit registers is for the operating system and I/O; the other is for user programs. Execution time is 1 microsec for an add operation, register-to-register. The machine has more than 200 instructions.

NOTES

An inexpensive universal feeder*

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Those that have dared deviate from usage of Ss that reliably respond for uniformly shaped pellets have frequently encountered difficulties in dispensing appropriate reinforcers. One solution, although an expensive one, is a universal feeder. While such a mechanism permits distribution of a variety of rewards, including such irregularly shaped objects as brine shrimp, tokens, candy, raisins, or bits of fruit, the cost of this apparatus may be prohibitive (Davis Scientific Instruments, Universal Feeder Models 310, \$523; 320, \$737; and UF-100, \$610).

A universal feeder that will reliably dispense diversely shaped objects can be easily constructed, and its cost is negligible. The feeder described here was built with a salvaged typewriter, for a materials cost of \$20, and its performance is comparable to that of a Davis (Model 310) feeder that is also being used in our laboratory.

The typewriter (Fig. 1A) can be any scrapped manual or electric model that has its tabular stop system and carriage assembly intact and operative, although an extra wide carriage maximizes the number of reward-holding compartments. The dispensing tray (Fig. 1B) was constructed with a 3-in.-wide longitudinal section of a 6-in.-diam Plexiglas tube and is equal to the carriage in length. The tray's 54 reward-holding pockets are approximately 1.27 x 1.27 x 7.62 cm, with a liquid capacity of about 8 cc (36 pockets in the Davis Model 310). The pockets were built by cutting grooves in the tray into which Plexiglas separators were affixed. The center-to-center distance between these pockets equals the distance selected between tabular settings. Therefore, larger rewards may be accommodated in wider pockets with the appropriate distance between tabular stops. Since the distance between pockets is easily adjustable by changing the tabular stop settings, versatility can be obtained by using relocatable pocket separators. The tray was then mounted on the carriage assembly after removal of the platen. In addition to

Fig. 1. The universal feeder consists of (A) typewriter base, (B) dispensing tray with reward-holding compartments, (C) drive motor, (D) cycle cam, (E) dispensing brush, (F) cycle microswitch, and (G) cleaner bar guard.

automatic indexing, the tray may be moved manually by activation of either the carriage return or the carriage release lever.

Dispensing is accomplished by means of a motor-driven brush (Figs. 1C and 1E) that rotates through each reward holding pocket, brushing the contents over the edge of the dispensing tray. Commercial feeders include a brush cleaning bar which dislodges a reinforcer that momentarily adheres to the dispensing brush. Such a bar was fitted here, but it was soon noted that if a reward such as a raisin did stick to the brush, the reward frequently was dislodged at an erratic angle and did not drop down the tube to the animal. Therefore, the cleaner bar was enclosed in a plastic bottle (Fig. 1G) which appropriately guided the flying reinforcer.

Dispensing occurs when a pulse activates a holding relay which completes the circuit that operates the motor. In addition to the brush, the 60-rpm motor also turns a cam (Fig. 1D). At the end of the dispensing cycle, this cam causes a microswitch (Fig. 1F) to open the holding relay, thereby turning off the motor. Indexing is then achieved by solenoid activation of the tabular key. This entire dispensing-indexing cycle requires about 1.5 sec, with the reward delivered in about 0.5 sec, compared with 2.5 and 1 sec, respectively, for Davis Model 310. Apparatus vibration during indexing increases as a function of the distance the carriage travels between stops. In order to avoid potential disruption in the Ss' performance, the feeder and the testing apparatus should be mounted separately.

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