

BPR 10-19 SPRING 1973

# Bulletin of Prosthetics Research

PROSTHETIC AND  
SENSORY AIDS  
SERVICE

DEPARTMENT OF MEDICINE AND SURGERY  
VETERANS ADMINISTRATION · WASHINGTON, D.C.

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Library of Congress Catalog Card No. 66-60273.

Distribution: CO: (00) (001) (10) (10A) (10E1) RMD  
SS (121 B) ( 1) (11A1) (11A3) (11F) (111) ( 12)  
SSD (113) (117) (118) (121) (122) (126)  
(15) (151) (152) 1 ea.  
FLD: HA, DO, OC, OCRO in varying quantities  
EX: P, DL

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# GAMES FOR THE SEVERELY DISABLED

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## INTRODUCTION

The endeavor to satisfy both the physical and the mental needs of the severely disabled has always been a challenge for the medical profession; more recently, the engineering profession has been performing a key role in meeting this challenge. The Bioengineering Research Service of the Veterans Administration Prosthetics Center has developed and evaluated many devices and systems which ameliorate the tasks of daily living of the incapacitated veteran.

A percentage of this effort is presently being directed into the development of "games" for the spinal-cord-injured patient. Enabling the quadriplegic to initiate and operate games gives him one more *independent* function in life. The ability to participate in these games not only proves entertaining and relaxing, but also affords these incapacitated persons competition between themselves or with "normal" individuals. This increases their mental activity and satisfies many normal human drives. The involvement of the patients in these games gives them a diversion from their otherwise limited activities. In participating they must think, act, react, and plan strategy during the *contest*. But, due to their physical handicaps, the spinal-cord-injured patient cannot operate commercially available games. The bioengineers at the VA Prosthetics Center have developed controls and internal modifications to avail commercial games for use by quadriplegics and other similarly severely disabled patients.

Design of patient-game interface control requires a knowledge of the physical limitations of even the severest disability encountered. The games that were modified at the VA Prosthetics Center used quadriplegics in particular to ascertain their criteria. Chin motions and breath pressures appeared best for designing the controls. For chin control, either of several joystick systems could be made operable for control by

a quadriplegic. The outermost portion of the joystick is formed into a cup for comfortable chin placement. The available omni-directional joystick control can be of the *displacement* type, where potentiometers are used in a servo system of a joystick switch array, to control various game drives directly, or of a *digital* type of joystick to control transistor logic circuits. Another type of chin control uses touch switches, which requires a small but positive force for activation. The use of breath pressure (positive pressure, or blowing, and negative pressure, or suction) easily operates pneumatic switches. The above-mentioned switches and controls are the interfacing mechanisms which allow the quadriplegic to initiate and participate in various games.

### **PINBALL MACHINE**

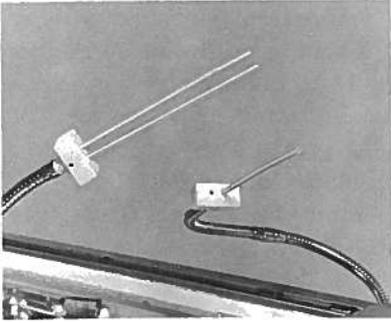
The pinball machine shown in Figure 1 was modified for quadriplegic use. The legs were slotted for adjustment to wheelchair patients, which enables them to observe fully the progress of the game. The patient plays the game in his wheelchair from a position where he can reach the straws used to operate the game. Straws are stored in a container on the side of the machine and are changed periodically for sanitary reasons, either by the disabled person himself or by someone else. Through use of gooseneck tubing, the pneumatic controls can be positioned in many directions and distances from the machine (Fig. 2). This allows the game to be used from different types of wheelchairs and by patients with various conditions. The quadriplegic "puffs" on the right-hand straw to start the game (sets score to zero and places ball in shooter alley). He then sucks on the same straw to withdraw the plunger. The plunger is released when he stops suction, and the ball is shot onto the playing field. The player now uses the left pneumatic controls, using a puffing action, to operate the two flippers (individually or simultaneously) which, when activated, hit the ball back onto the playing field. There are additional adjustments in the machine which may add to patient interest: The game may be set for either free use or for a preset number of plays that must be paid for (e.g., a nickel, which would go into a "party fund" for all the patients); the award of an extra ball can be preadjusted to correspond to a certain score, which would be an indication of skill.

The internal drive system (Fig. 3) used in the pinball game consists of a printed d.c. torque motor, electromagnetic clutch, and connecting linkage to the standard plunger. The average spring used on the plunger requires 1½ lb. of force to initiate motion and 5 lb. for full excursion. This is accomplished by using a d.c. permanent magnet printed motor that generates a speed and torque at its output which is proportional to its input voltage. It can be operated at several different voltage levels;



FIGURE 1.—Pinball game, modified for quadriplegics, with pneumatic controls and slotted adjustable legs.

the output torque is extremely high, and the effective speed ranges from zero to several thousand revolutions per minute. The “pancake” style is possible because of the armature construction (i.e., it is disk-like and flat as compared to conventional, cylindrical-shaped armatures). This “pancake” design simplifies positioning of the drive system within the machine. The power transmission is through an electromagnetic clutch, giving a low inertial system upon release. From the clutch’s output, a

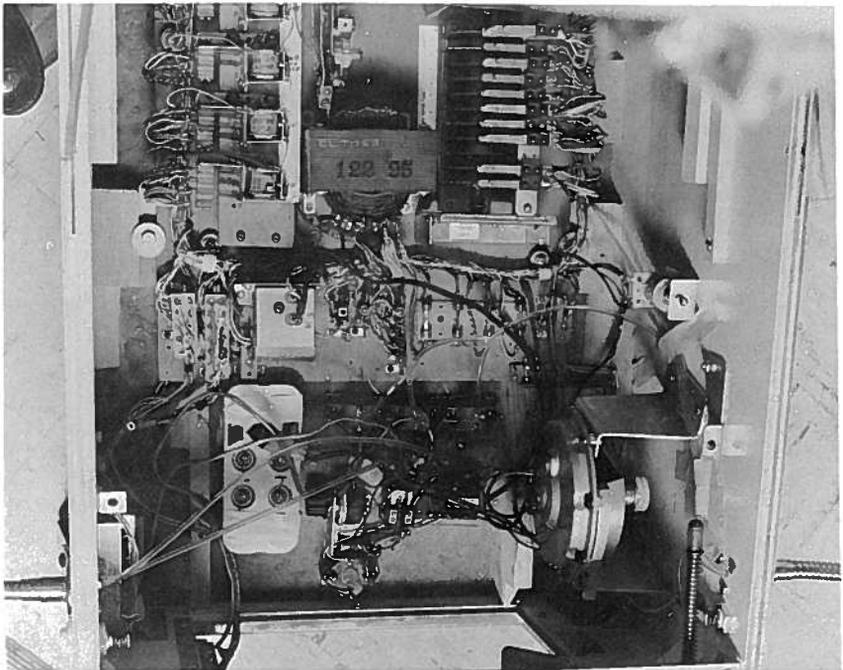


**FIGURE 2.**—Closeup view of pneumatic controls showing replaceable straws and adjustable goosenecks.

linkage withdraws the plunger to any position. Both the motor and clutch are under the full control of the operator via the pneumatic switches. The game may also be played in the conventional manner.

### **ODYSSEY GAME SIMULATOR**

Odyssey, an electronic game simulator, was also modified for quadriplegic use. The Odyssey simulator involves electronic squares (objects)



**FIGURE 3.**—Lower section shows the pneumatic switches which control the internal drive system and operate the various controls of the pinball game.

displayed on a television screen. The T.V. screen is covered with an overlay (game pattern or playing field). There is a different overlay for each game. The overlays are sized for any 18- to 25-inch television screen. The game is played by manipulating the electronic objects on the T.V. screen appropriately for that particular game. Two patients, or a patient and a "normal," can compete in the many games available through the use of the various overlays. Some of the games that can be played with Odyssey are: ping pong, tennis, football, hockey, skiing, submarine, cat and mouse, haunted house, analogic, roulette, geography quiz, etc.

Only external modifications were necessary for the Odyssey game (Fig. 4). A chin-controlled joystick system was developed to replace the standard hand controls. The game played determines the number of electronic squares displayed on the T.V. screen. Two squares represent the "players"; a third square represents the "ball." The chin control system was designed to enable the quadriplegic to manipulate his "player," release the "ball" into play, and put "English" (a spinning or curving motion) on the ball.



**FIGURE 4.**—Odyssey game with external modifications. Shown is a chin bracket with chin control on horizontal bar.

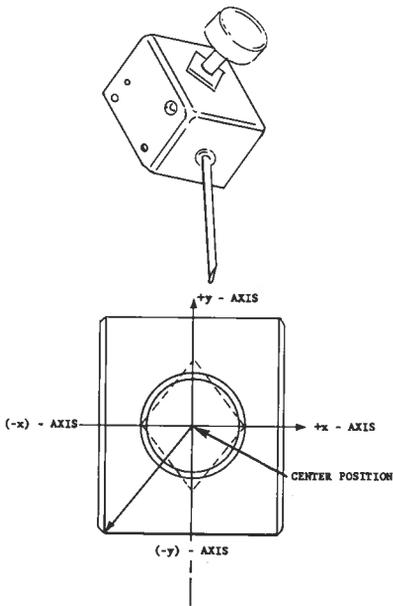


FIGURE 5.—Diagram depicting movement of joystick control in an X-Y plane.

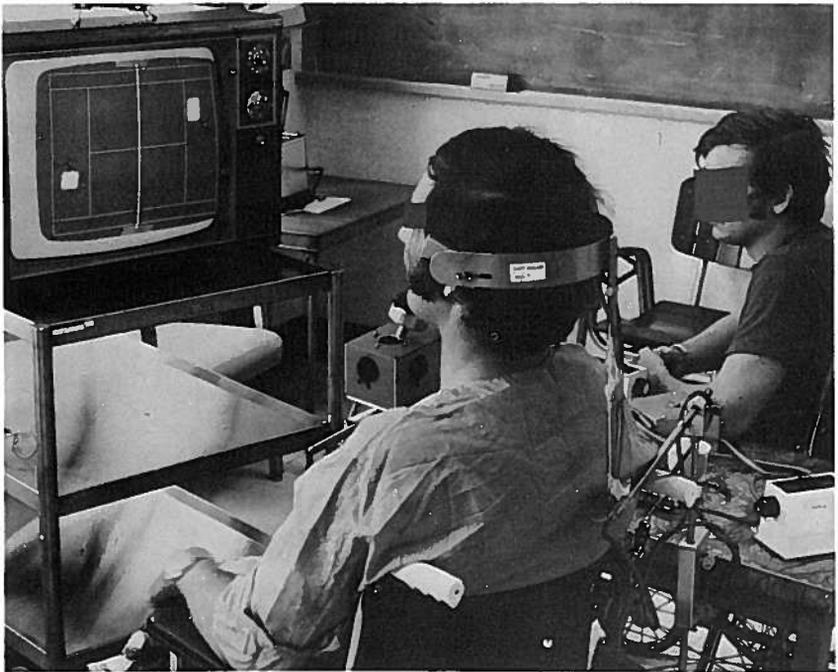


FIGURE 6.—Veterans competing in Odyssey game.

The joystick of the chin control can be described as operating on an "X-Y" plane (Fig. 5). Movement of the joystick from its central neutral position along the X-axis or the Y-axis will move the "player" horizontally or vertically, respectively, on the T.V. screen. An angular movement in the upper left X-Y direction or the upper right X-Y direction will apply proportionally left or right "English" on the ball, respectively. The extreme lower left X-Y position releases the ball into play (RESET FUNCTION). Figure 6 shows quadriplegics at a VA hospital operating the modified controls of the Odyssey game.

### **FUTURE PROGRAMS AND CONCLUSIONS**

For various other games, controls similar to the above may not be adequate. The Bioengineering Research Service is experimenting with solenoids and several positioning systems and remote manipulators for operation of an expanded variety of games. A number of feasible games that can be made operable by quadriplegics are: scrabble, chess, backgammon, roulette, cards, various bowling-type games, sport games, model-making, painting, drawing, auto-driving simulators, labyrinth, model cars and trains, and flying model airplanes.

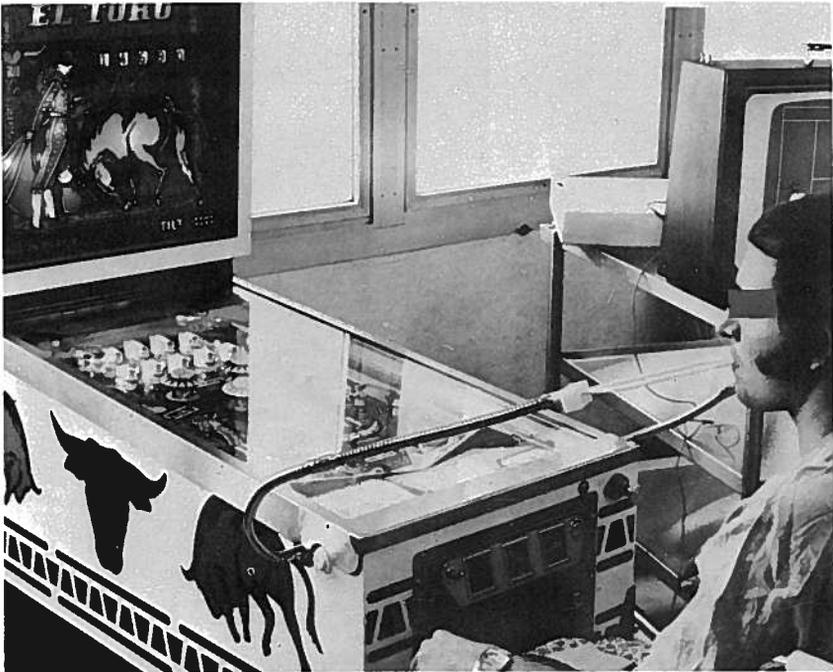


FIGURE 7.—Quadriplegic clinically evaluating modified controls of pinball game.

All of the above games involve moving objects in space. The remote manipulators needed to perform these activities would be a big step in making a quadriplegic independent in *many* functions of daily living, including recreation and hobbies.

The modified pinball game and the Odyssey game were evaluated by quadriplegics at the VA Hospital, Bronx, New York, and the VA Hospital, Miami, Florida (Fig. 7). Their reactions were highly enthusiastic, and the program is now in the process of being expanded by providing more games to various Veterans Administration Hospitals throughout the country.