The Mobile Automaton

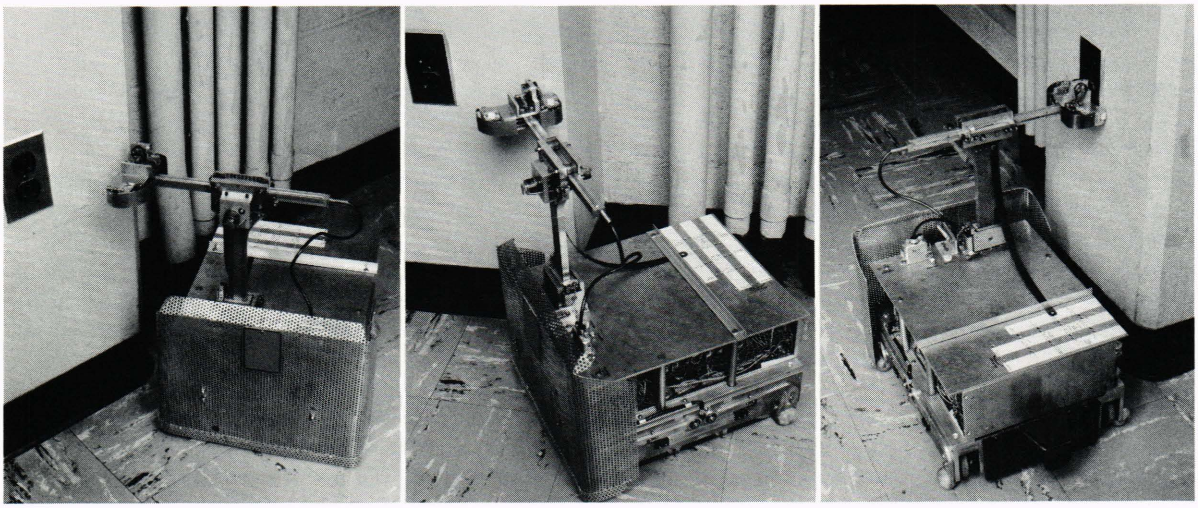
In the course of APL studies of adaptive functions, a primitive automaton was constructed that could operate independently for relatively long periods of time in an unmodified environment. This machine was the result of a cooperative research effort directed by A. G. Carlton.

When first conceived, design of the automaton had to provide for two important survival mechanisms: the abilities to replenish its energy supply whenever necessary and to cope with obstacles in its path. The most convenient energy source available in the automaton's environment is, of course, the electric power available at wall outlets situated throughout the halls. It was decided, therefore, that the automaton should be able to plug itself into these outlets whenever it became "hungry." This, in turn, required that the machine have a power supply of rechargeable batteries, silver-cadmium cells being subsequently chosen. When the supply of energy in these cells is reduced to a predetermined level, the automaton automatically attempts to plug into and feed from the next outlet that it encounters.

The mechanism by which the device finds a socket is relatively simple. The machine's usual mode of operation is to feel its way along walls by means of a servo-actuated retractable probe arm, on one end of which two microswitches keep contact with the wall. Two other microswitches on the end of the probe are so located as to sense the contour of an electric outlet cover plate. When such contact is made, the vehicle stops and two prongs are inserted into the socket, by action of a second servo, to draw current. If current is drawn, the automaton remains motionless until the ammeter shows a sufficient charge; the prongs then withdraw and the vehicle moves on. On the other hand, if no energy is available, the prongs immediately retract and the vehicle seeks another outlet.

The machine can also move around obstacles and avoid falling down stairs. A wrap-around bumper on the front of the automaton is equipped with sensors which signal the presence of an obstacle. When this occurs, the machine backs and turns so that when it resumes forward travel it tends to move around the obstacle. Stairways are avoided by actuation of loss-of-support sensors mounted just forward of the wheel treads. Normally, these four sensors rest on the floor, but when this support is removed they fall and automatically signal the vehicle to stop, back, and turn.

The hallways which are this automaton's environment are cluttered with many such obstacles as door jambs, I-beams, vending ma-



Mobile automaton is shown (left to right) approaching an electric wall outlet, with its retractable probe arm in contact with the wall, and in the "feeding" mode with its two prongs inserted in the socket.

chines, and staircase banisters over which the probe arm, or boom, will not roll without being retracted. The need to retract is sensed when the stanchion that supports the boom is deflected inboard from the vertical, thereby actuating a microswitch. Another switch signals the condition of the head, when it is caught behind a pipe or banister, by sensing the outboard tilt of the stanchion when it tries to retract the boom.

Signals from the several microswitches are fed to the logic control unit located in the upper half of the automaton body. This control includes all of the decision-making functions needed for the vehicle to exhibit a response appropriate to each set of input signals. The latter, representing the entire environment of the machine, are mostly in the form of on-off conditions of various microswitches and represent 17 different Boolean variables. The control section is a logical network that accepts these inputs and generates a set of outputs, comprising six Boolean variables that determine the entire behavior of the automaton.

The device has survived entirely on its own for as long as 21 hours. During this period of continuous movement around a closed path of two halls and two connecting corridors, it "fed" from four available electrical outlets about 25 times.

Plans have now been made to modify this model to give it a greater operational capability in the form of a higher "intelligence." Active acoustic guidance will be added to allow the automaton to move down the center of a hall, contacting the wall only when it is actively seeking a "feeding." A normal forward speed of twelve inches per second, which is twice the present speed, together with a slow speed of three inches per second for obstacle avoidance and the feeding phase, will be incorporated. Finally, provision will be made to allow the automaton to search vertically for electric outlets since, in the present model, only those few at a certain height can be used. Such other modifications as optical guidance and neuron analog devices are also anticipated in the future.

Polaris Fluid Magnetic Spring

A fluid magnetic spring that provides suspension characteristics and acts as a variable damping and lockout device has been developed at APL for the Polaris missile and tube launching combination on Polaris submarines. The new spring is the work of R. E. Kemelhor.

The most common form of "liquid spring" is the conventional automobile shock absorber in which a hydraulic fluid is both compressed and metered through an orifice when the shock strut is subjected to suspension loads. In general, the force it transmits increases approximately as the square of the telescoping velocity; thus, when a fast-moving automobile travels over a bumpy road the shock absorber becomes very rigid. What was required in the Polaris program was a means of varying the "sponginess" (damping characteristics) of the liquid spring under shock conditions from "smooth" to "very rough."

The concept developed at APL is based on varying the viscosity of the working fluid by electrical control. The working fluid consists of a mixture of oil and iron particles rather than oil alone as in the case of the automobile shock absorber. When the mixture is passed through a magnetic field, the fluid can be changed through a range of viscosity from that characteristic of comparatively light oil to an almost rigid, mud-like consistency. Thus, by sensing the telescoping action of the shock absorber by means of a simple potentiometer mounted on the plunger, the viscosity of the unit can be automatically controlled. In addition, it is possible to control the electrical input manually so as to set the shock absorber to a desired stiffness.

The liquid spring illustrated shows the method of blocking the damper element by magnetically solidifying the fluid flowing through it. This isolates the most compressible fluid volume and renders the spring comparatively stiff when lockout is desired. Nonmagnetized operation of the spring is similar to that of a conventional liquid spring. When the spring is either extended or compressed, pressure in the Cellulube[1] volume is raised, forcing the magnetic fluid to flow through the

[1] Cellulube is a new non-petroleum-based, fire-resistant hydraulic fluid; it is a product of the Celanese Corporation.