MACHINE DESIGN
A PENTON/IPC PUBLICATION
MARCH 24, 1983

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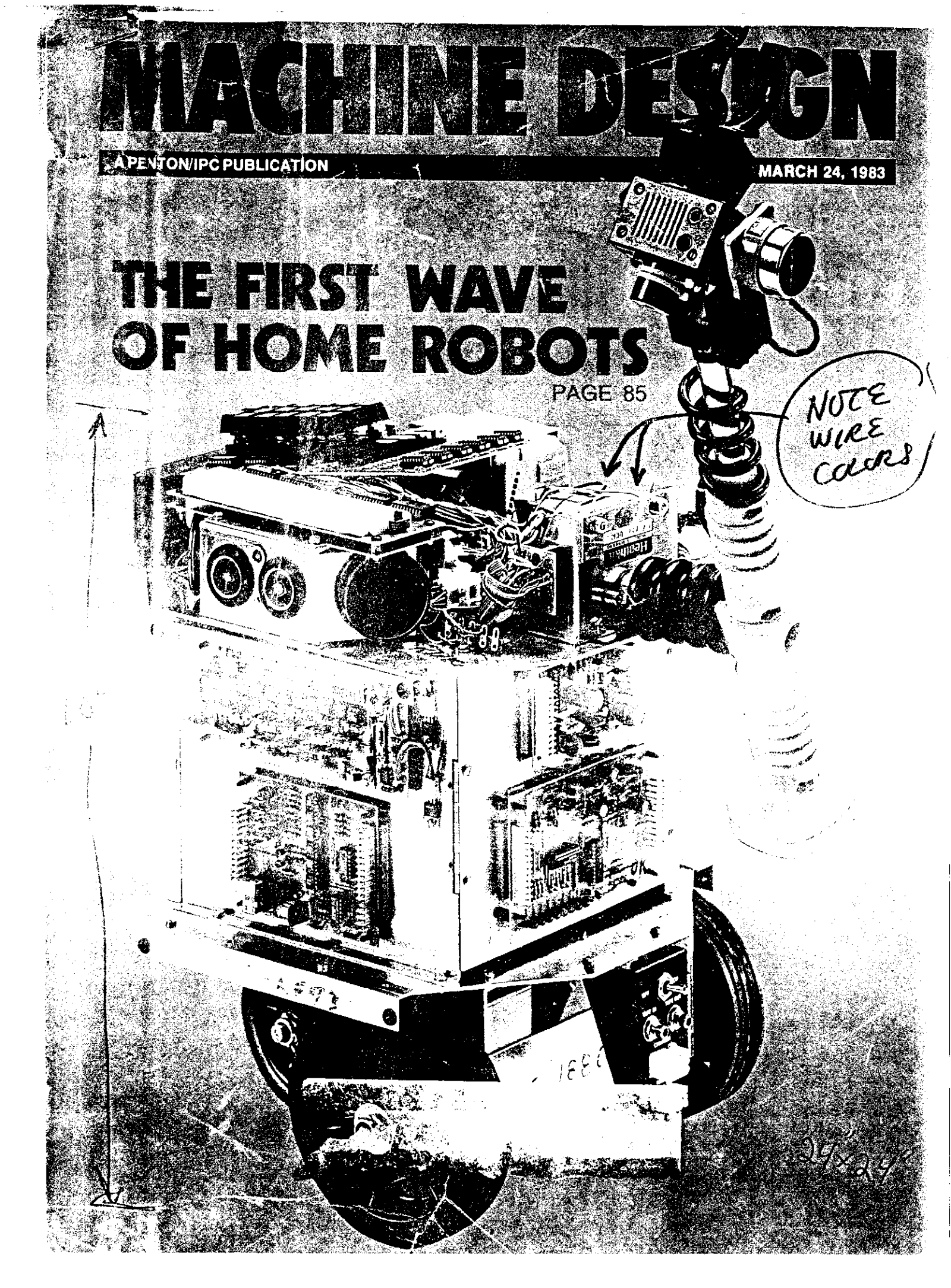
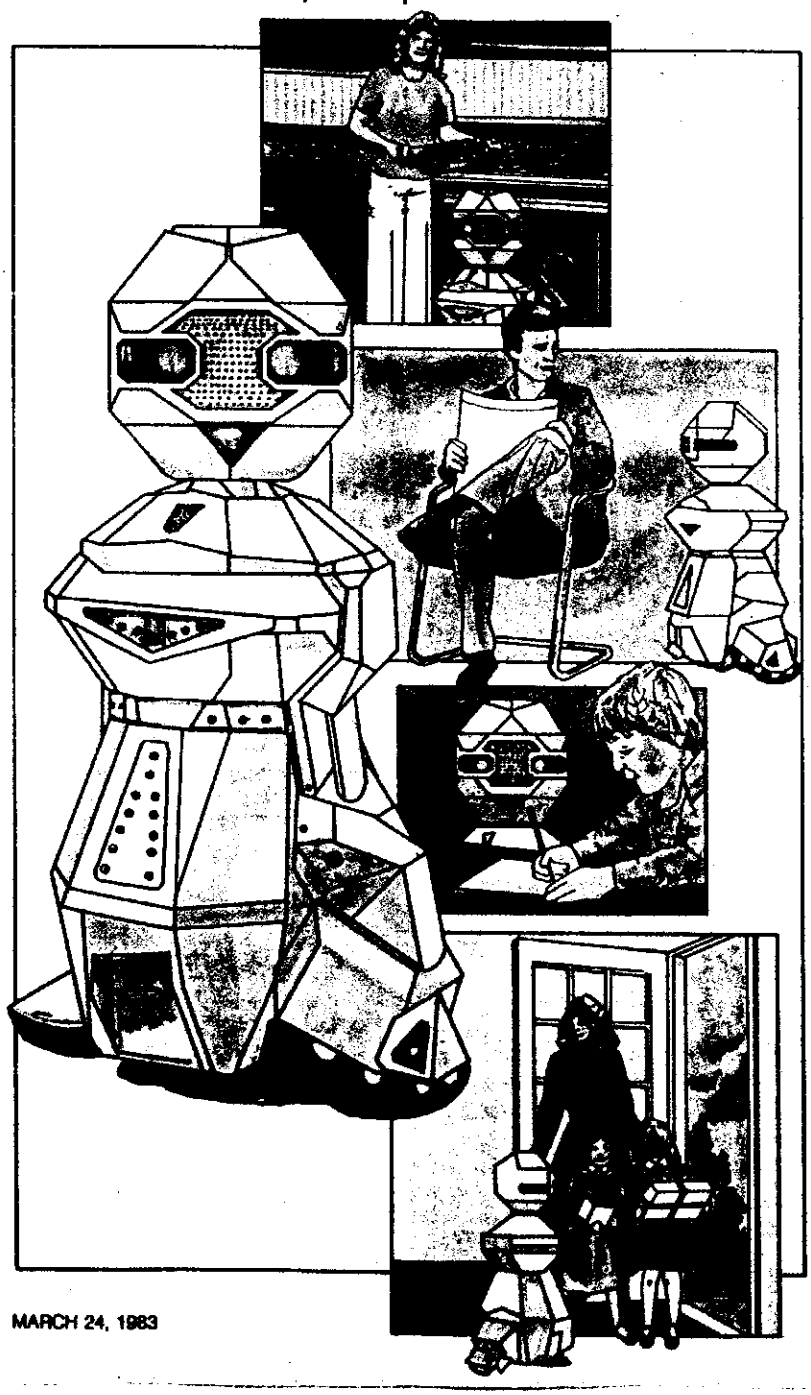
PAGE 85



THE FIRST WAVE OF HOME ROBOTS

They walk, they talk

New generations of robots won't all be stationed in factories. Innovative home robots have already started toddling into living rooms across the country. These clever machines can walk, talk, avoid obstacles, and even recognize simple spoken phrases.



LELAND TESCHLER
Staff Editor

FIVE years ago, virtually no one was predicting that personal computers would become household fixtures. Those who had the audacity to make such suggestions generally were met with ridicule. After all, the personal computers available back then couldn't really do much, and many doubted whether the small machines would ever be more than diversions for weekend hobbyists.

The mushrooming personal-computer market has made it easy to forget these modest beginnings. But the experience may keep doubters from lightly dismissing a new technological toy, the home robot. At least four companies already are marketing mobile robots ranging in price from about $1,000 to $8,000. These devices in many cases can talk, sense objects, and recognize a few spoken words. And indications are that other companies are getting ready to offer similar products.

The first question most people ask about these devices is "What good are they?" Manufacturers admit that first-generation home robots cannot do meaningful household tasks. "If you expect it to wash windows or clean dirty dishes, you're going to be disappointed," remarks Heath Co. education director Douglas Bonham. Late last year, Heath introduced a home robot called Hero I (for Heath educational robot) as part of a directed-study robotics course.

As with the first personal computers, home robots will likely find their first market with tinkerers and hobbyists. Robot makers say they are counting on these individuals to develop much of the underlying technology for personal robots, just as a great deal of the software that made personal computers successful came from independent authors working on their own.

Until that underlying technology catches up, robot companies expect that hobbyists will use their robots for "software intensive" purposes that don't require complicated movements with robot arms or other appendages. "Practical uses now include things like security, answering the telephone, playing games, or fetching things using some sort of external equipment," says Androbot Inc. engineering director Frank Jones. Androbot, a start-up company established by Atari founder Nolan Bushnell, recently released two home robots, B.O.B. and Topo.

Robots designed specifically to take over additional domestic chores may be just around the corner, however. Two manufacturers hope to have such products ready for introduction by the end of the year. The RB Robot Corp., a manufacturer that recently released an experimenter's robot called the RB5X, aims soon to market a consumer model. "Many of the features are still up in the air," cautions RB Robot president Joseph Bosworth, "but the consumer model may be able to retrieve a drink from a special dispenser we are designing. Vacuuming a rug will be a possibility because it will be able to map out a room, then find a closet to get a vacuuming attachment."

Another consumer robot called Genus from Robotics International Corp. is also expected to be ready by year end. Genus will have a vacuuming attachment and will be able to lift five-pound loads with its built-in arms. (Other units equipped with arms can lift one-pound loads at best.)

I, robot

Company officials at Heath have already accumulated a host of stories about the exploits of their Hero I. Small children, seeing Hero roaming around and talking in consumer electronics stores, have been known to come up and hug him. "They relate to it like it was E.T.," say Heath officials. One man came into a store with his young grandson who, seeing Hero, immediately went bug-eyed.

"Do you like it?" the man asked. The response was strongly in the affirmative, so the man bought the $1,500 kit on the spot.

Company officials have had to tote Hero through numerous airport check points because the robot travels in the passenger compartment housed in its own trunk. Security personnel invariably ask to see the contents. Engineers at Heath have programmed the robot so that once the lid opens and the robot senses light streaming in, its voice synthesizer mutters an oath and thanks the person that let it out of the "stuffy" box. This routine reportedly has sent airport security guards across the country into hysterics.

The features that allow home robots to pull such antics include on-board computers, voice-synthesis circuits, sophisticated motor-drive systems, and a number of on-board sensors. Many of the robots use ultrasonic transmitters and receivers to locate objects. (Most of these ultrasonic sys-

Looking up to a Hero

Three years ago, Heath Co. was looking for a way to provide a hands-on training tool to go with a programmed-learning robotics course their educational division was developing. The result was the Hero I home robot. Since its introduction, Hero seems to have caught the imagination of the entire country. It has appeared on national TV news programs and been featured in publications ranging from *The Wall Street Journal* to *Byte*. The first production run of several hundred Heros was sold out instantly and a second run is almost entirely sold even before assembly has started.

The robot that has caused this commotion stands 20 in. tall and weighs 39 lb. It is physically reminiscent of the R2D2 robot of *Star Wars* fame, with its rotating turret-like head. Hero's head also carries its arm mechanism, programming keyboard, and experimental circuit board.

It can be programmed to pick up small objects with its arm, synthesize complete spoken works, or even recognize simple spoken words. ?

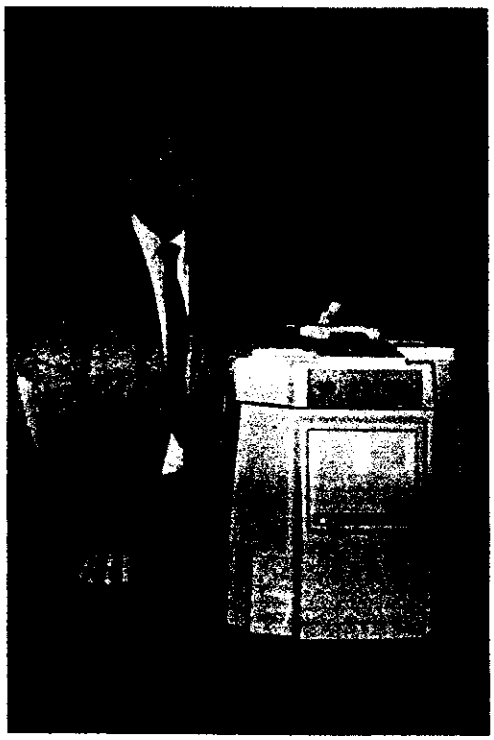
Heath engineers have already found a few imaginative ways of showing Hero's capabilities. To demonstrate how the robot synthesizes and recognizes voices, for example, one engineer programmed Hero with a numbers game. In this game, someone tells Hero a string of numbers, and he repeats the last spoken number in the string. The second time he hears a string ending in the same number he says, "This is a boring game. Can we do something else now?"

Despite the comical antics, Hero can also be an effective tool for teaching robotics, point out Heath officials. The robot, which costs about $1,500 in kit form or $2,495 when fully assembled, incorporates many principles that are common to industrial robotics.

B.O.B. and his brother Topo

Having already successfully formed Atari Inc., Pizza Time Theatre, and Catalyst Technologies, entrepreneur Nolan Bushnell in 1981 decided that home robots could someday be as popular as personal computers. The result of this thinking was the formation of Androbot Inc.,which in

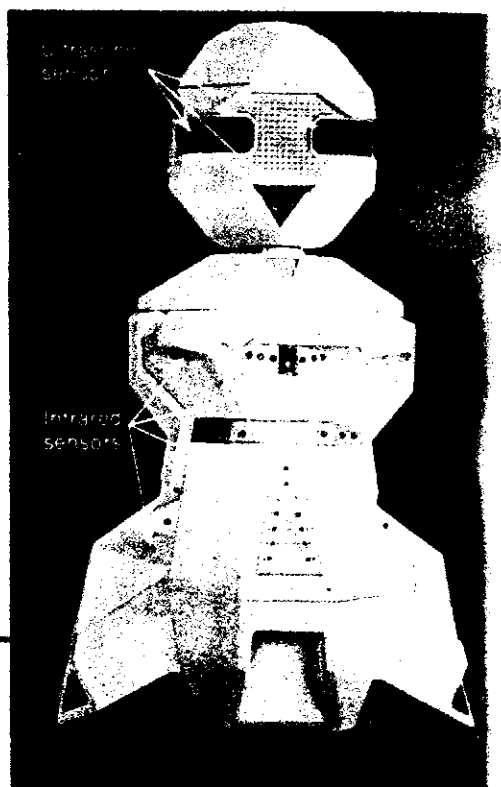
The mechanical arm designed for Hero, shown here with cover removed, consists of a pancake stepping motor at the end of a lead-screw mechanism, which is used to extend or retract the wrist and gripper. Separate stepping motors power the wrist mechanism and plastic gripper. When fully extended, the arm can hold 8 oz.



The Hero I, here with chief designer James Lytle, stands 20 in. high.

tems use hardware developed by Polaroid for its autofocusing cameras.) Some also employ light sensors. Androbot B.O.B., for example, detects the presence or absence of the floor in front of it by searching for reflections from one of its infrared sources. The robot thus can be programmed to automatically stop before toppling down a flight of stairs or stumbling into some object. The RB5X robot, on the other hand, feels its way through a room by bumping into walls and objects which actuate one of a band of microswitches located around its body.

Robots generally speak through commercially available phoneme-based voice-



January released is first products: home robots Topo and B.O.B. (for Brains On Board). B.O.B. costs $2,495 and contains three computers and five ultrasonic sensors which locate and measure objects in its immediate vicinity. Some of these sensors are pointed at the floor so that B.O.B. can sense when he is coming close to an edge or stair step. Two infrared sensors allow B.O.B. to differentiate between humans and inanimate objects.

Unlike B.O.B., Topo does not contain its own computer. It has been designed to operate from commands sent by a conventional home computer, by means of a radio link. In this fashion, the $1,195 robot can be controlled through the same joysticks used for video games.

B.O.B. and Topo share many of the same vital statistics, use the same molded plastic body, and stand on only two wheels but are inherently stable, even when at rest. This support system is so unique that Androbot has applied for a patent (See "Scanning the Field," MD 3/10/83). The 3-ft-high robots are powered by three gelled electrolyte sealed batteries. Both can move at about two feet per second through use of two high-torque motors.

synthesizing circuits. Through this method, robots can say any English word (and words in some foreign languages) by stringing phonemes together. (Phonemes comprise the basic sounds which make up all spoken words.) The resulting speech remains machine-like but understandable.

An operator can program the robots, in most cases, either by entering commands on a built-in computer keyboard or by plugging the robot into a personal computer and having the desktop unit control the robot through an umbilical cord. The Heath robot comes with a teaching pendant, similar to the pendants used to lead industrial robots through tasks. The operator can control robot speed and direction with push switches. If the robot is equipped with its optional arm, the pendant can also control arm position to pick up and move objects with the arm grippers. And just as in its industrial counterparts, the Heath robot can memorize movements entered with the pendant and repeat them on command. In addition, at least two home-robot companies plan to produce add-on devices for controlling robots by radio link.

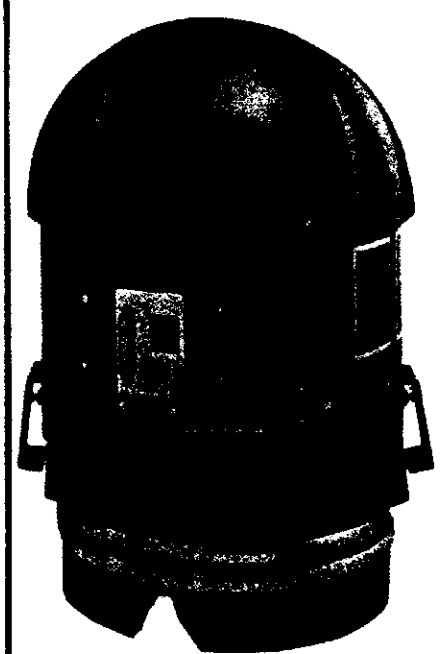
There appears to be no clear preference for any particular brand of microcomputer among robot manufacturers. Hero uses a 6808 8-bit microprocessor. The RB5X uses an 8-bit INS8073, while Androbot B.O.B. uses three 8088 16-bit processors. Genus will probably contain an 8086. Manufacturers choose different computers for various reasons. For example, Heath employs an 8-bit device because the company feels it provides sufficient speed for the robot's mechanical control. Besides, says Heath, 8-bit processors are easy to program, an important factor for the hands-on teaching that Hero was designed to provide.

Androbot B.O.B., with its three 16-bit processors, may be the most sophisticated home robot yet devised. Officials at Androbot say that they wanted to furnish B.O.B. with a means of running large and sophisticated programs, and at least three 16-bit processors seemed to be required.

Each processor in B.O.B. is dedicated to a different set of tasks. One handles sensors and perception, another handles location-finding and motor control, and the third runs the operating system software, makes decisions, and generally acts as an executive computer. The robot is capable of carrying over three megabytes of main memory. And because the robot employs the same kind of microprocessors as the IBM pc, robot programs probably can be developed easily on IBM-compatible personal computers.

However, computer programming may be one of the least difficult links in getting home robots to perform meaningful tasks. A lot of clever electromechanical design will be required, say robot manufacturers, to provide inexpensive ways of manipulating ob-

RB the robot



The home robot field attracts its share of entrepreneurs. One such individual is Joseph Bosworth, founder of the RB Robot Corp. Bosworth, a former consultant for the Solar Energy Research Institute, had a background in computers but, he says, "I didn't want to get into the same things that everybody else was doing. So I was looking for the next frontier." It didn't take much looking, he says, to see that home robots could be to robotics what the Apple II personal computer was to computers.

The Golden, Colo., company's first attempt at an experimentor's home robot (they anticipate introducing a pure consumer version later this year) is the RB5X. The 2-ft robot sells for $1,195 for a basic model with additional memory, sonar sensor, and pulsating light options available for $295.

Weighing 10 lb, the unit is equipped with tactile sensors about its body, allowing it to detect and respond to objects in its path. Its basic motivation is to keep moving. When its tactile sensors touch an object in its path for the first time, it will choose from a table of random responses. It will either turn left, right, back up, go forward, or stop for a short time. Successful responses are stored. As the robot's experience grows, it develops rankings or levels of confidence in each of the possible responses. Eventually, it builds up a range of appropriate learned responses to all the objects it may encounter in a room. The unit can be programmed from an external personal computer through its RS-232 interface. It can also charge its four C and D-cell power supply automatically, seeking out and attaching itself to its charger, then uncoupling and resuming its activities.

jects. The feeling is that no one company will make most of the required breakthroughs. "It will require a marriage of individuals and companies," says Bonham of Heath. "The hardest part is that we'll be plowing new ground." For these reasons, Heath thinks that the home-robot market will grow much more slowly, at first, than the home-computer market did.

The importance of tinkering

Robot makers say that mechanically inclined individuals are bound to make important contributions to the field. One individual who seems to fit this mold is Douglas Jones, a development manager with Androbot. Primarily because of Jones, the Androbot robot has a unique support structure which allows it to stand on only two wheels and remain stable without any other support. This stability comes from the use of canted wheels. The design remains stable for much the same reason that a rocking chair does not tip over as it rocks: The effective roll center is above the center of gravity. The principle is clearer when the robot is viewed from the side. The side projection of the wheels looks like an ellipse with the long sides resembling the rail of a rocking chair.

The support is so novel that Androbot has applied for a patent. The patent application cites Jones as the primary inventor. Of the seven technical managers on the robot project, Jones is the lone engineer without a degree.

Jones, along with manager of mechanical engineering Sigfried Salat, designed the mechanics and the molded plastic robot body. "I've been a designer for about 17 years now, and I'm basically self taught," says Jones. "I taught myself how to do trigonometry, but I didn't use any of the conventional systems. I wanted to create a different way of doing projections for molding the robot body."

Jones admits that he got the idea for the canted wheel support in an off-beat way.

"I had to build something else that had two canted rollers," he explains, "but they weren't used as wheels. I noticed the stability and put the idea on the shelf for a year. Another source I relate the idea to is a TV commercial I saw. In it an oblong sleeping pill rocks slowly back and forth."

Because the contributions of independent inventors and software writers promises to be important, robot manufacturers are willing to go to great lengths to provide encouragement. Androbot, for example, has already announced a royalty arrangement for software writers. The company is even willing to design attachments for the robot to do tasks like lawn mowing and vacuum cleaning, so long as authors of programs implementing these tasks sign a marketing agreement.

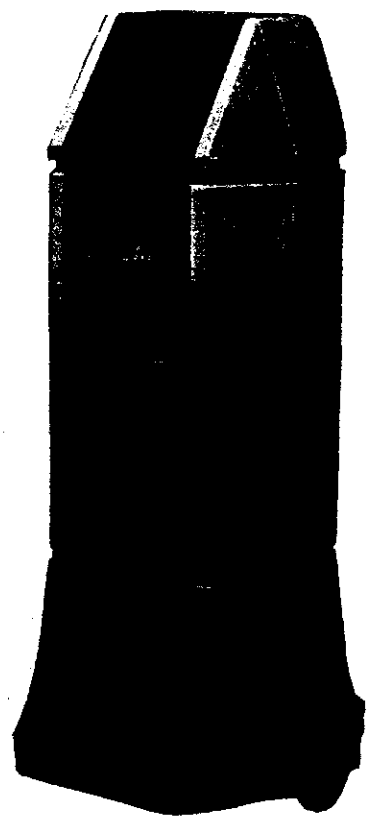
One program that Androbot engineers themselves are currently at work on allows the robot to perform household

Getting to know Genus

Simple mobile robots have worked trade shows, conventions, and shopping mall store openings for years. But these devices have generally been little more than platforms remotely steered by an operator who may also have put a few stale jokes in the robot's mouth by radio link.

Some of the techniques developed for these devices have been applied to home robots. One example of this fall-out is a home robot developed by promotional robot maker Robotics International Corp. The Jackson, Mich., firm used its background in constructing animated robots for Pizza-Time Theaters and other promotional vehicles to build Genus. When available later this year, the $10,000 to $12,000 robot will have options such as arms, a computer with 48K or more memory, voice-recognition, and speech synthesis.

Genus stands 4½ ft high and weighs 120 lb. It is mechanized by two 7-in. rubber wheels and also contains fore and aft casters. When its batteries are low, it seeks out its personal recharging outlet, homing in on the outlet by using its sensors. Two 12-V sealed lead-acid batteries provide an average time between charges of four hours. The robot's head contains a fully functional CRT display along with display buttons. Optical packages being developed include microwave motion detectors, an audio discriminator, passive infrared and smoke detectors, and a vacuuming unit which hangs on the front of the robot.



sentry duty. The robot will roam the house, using its infrared and ultrasonic sensors to detect extraneous humans. It will be programmed to recognize the proper occupants by some predetermined sign given as they enter the house.

Another duty Androbot engineers have thought about is using the robot as a mobile phone fetcher. The robot can be equipped with circuits that allow it to sense a telephone ringing signal. It will track down a house occupant who may then answer the phone through a radio link between the robot and phone lines.

The company is now at work perfecting the robot's first accessory, which will be another kind of fetching system. Reports are that the attachment will be a wagon able to carry four beverage six-packs. The wagon will be equipped with a mechanism that will allow the robot to, say, distinguish between different brands of beer and serve the proper brand on demand at parties.

Design criteria

Aside from the canted wheels on the Androbots, home robots introduced to date have not depended on any developments that could be termed technological breakthroughs. The hardest part of actually designing a home robot, say manufacturers, is simply defining the concept of what a home robot should be.

"We made a lot of false starts in the beginning," says Heath product line manager James Lytle, who was the chief designer of the Hero I. "We tried to find ways to keep the cost down, but there were a number of things that we eventually decided Hero just had to have despite the extra cost. Voice was one example. The robot took on such a personality with a synthesized voice that we decided it was a must."

The company also says that the form of the robot's arm was subject to much thought. The arm that Hero now carries is a tenth-generation design. The first arm designs moved only at the shoulder joint. But this approach was deemed too simple. In the final design Heath added a lead screw within the arm itself to extend a gripper. The company decided against using a conventional jointed arm because they felt that the mechanical disadvantage incurred in the elbow joint would limit its usefulness.

Other home robots use different kinds of arms. The RB5X is slated to eventually have a jointed arm as an add-on option. Androbot robots do not have arms as such but contain side platforms that fold out to serve as carrying surfaces.

A number of different techniques are also used in providing mobility. The Androbot, standing on its two lone wheels, contains two dc permanent-magnet brushless drive motors, one dedicated to drive each wheel. The robot has only to run one motor faster than the other to make a turn. This drive configuration also allows the robot to turn on its own axis. The robot keeps track of how far it has moved by monitoring optical position encoders mounted on each wheel.

The Heath robot uses three wheels, one drive wheel and two castors. Heath also uses a dc motor to provide power. The motor, an optical encoder, and drive-wheel assembly are mounted to a frame that is rotated by a second steering motor. Heath says that using a single drive motor simplifies the algorithm required for tracking and steering.

At least two companies use a four-wheel platform. The Genus robot from Robots International uses two drive wheels with two dedicated drive motors along with two nondriven wheels to provide support. The RB5X robot also uses a four-wheel platform and two drive motors, but does not employ shaft encoders to measure robot position. The robot will eventually be able to locate itself in a room through use of ultrasonic sensors. One reason robot manufacturers give for using a four-wheel platform is that it allows the robot to turn on its own axis, a feature that three-wheel platforms cannot provide.

Caveats

One advantage that home roboteers may have in the coming years is that industrial robotic techniques are undergoing intense development. Techniques perfected to provide versatility in industrial robots could well impact home robots.

Nevertheless, much remains to be done before robots become as necessary for modern living as a family car. If industrial experiences with robots give any indication, the acceptance of home robots may hinge on a number of subtle factors besides simple versatility.

In Japan, for example, three out of four industrial robots reportedly break down before running 1,500 hours, and almost one in three experiences problems before working 100 hours. The average homeowner is well aware that similar problems eventually crop up in any electromechanical device used around a home, and robots are probably no exception. All in all, it may be some time before personal robots become what the Japanese have called "tools of liberation" and create significant amounts of leisure in the home. MD