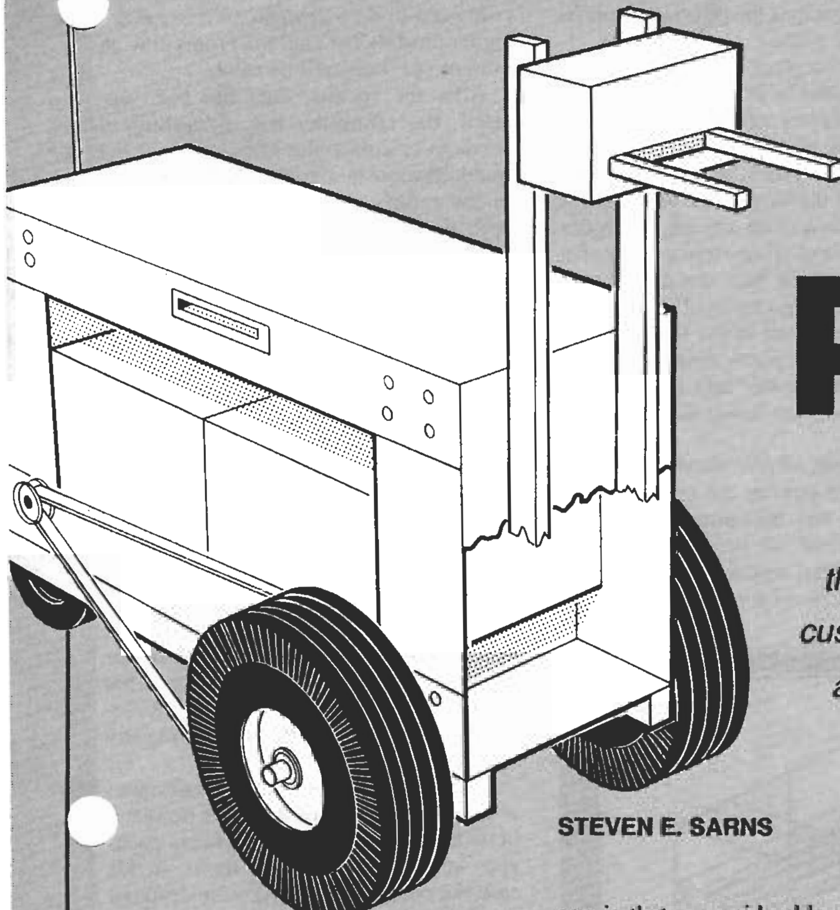

R-E ROBOT

You needn't be satisfied with a robot that looks and acts like all the rest. You can customize our robot to your heart's content—and share your designs with other readers!

STEVEN E. SARNS

THE BIG ONE FINALLY CAME THIS AUthor's way: a job providing both financial reward and a fascinating challenge for his company, Vesta Technology. The project: To design a robot, including a control computer, an arm, and additional subsystems for motion control, navigation, and operator input/output. While designing the robot, we discovered much about the personal robot industry. For one, it appears to be dominated by expensive robots with limited capabilities. We felt that a new approach could make a home robot more affordable and more exciting.

Designing a robot requires expertise in a number of areas, including mechanics, electronics, and computer hardware and software. In order to augment Vesta's limited abilities in the field of mechanical engineering, we enlisted Stock Drive Products to aid our development effort. That company is the major supplier of mechanical components to the industrial robotics market. See the Sources box for their address.

The cost of a robot

Stop for a moment and consider why personal robots are so expensive. One reason is that a considerable markup takes place at each point in the distribution chain. A manufacturer's purchasing department must have a secure supply of parts, so it may be willing to pay higher prices to attain that security. The hobbyist, however, has the advantage of being able to buy from less-expensive sources of parts. He can, for example, take advantage of surplus outlets, thereby eliminating middlemen; the result is a substantial savings over manufacturers' prices.

As for the controller, we designed a complete low-cost single-board computer that is highly compatible with the IBM-*PC*. Our approach emphasizes the use of flexible electronics that allow you to customize your robot with available mechanical parts.

By providing the electronic-control system and minimizing mechanical costs, we believe that building a personal robot can be both entertaining and affordable. In the upcoming series of articles, we will show you how you can adapt our designs to your problems.

The main components of our system are the single-board development system, a control/sensing board, and control software. Because the electronics systems are efficient and adaptable, you are free to interface them with whatever mechanical system meets your needs. The systems software that we have developed (and are still developing) is quite sophisticated, but the applications programming is left to you.

The bottom line is that we are not offering a kit for the type of ready-to-assemble robot that so many other companies offer; rather, we are suggesting that you can build the robot that you really want or need by integrating our control system with your mechanical design.

Overview

As we discuss the specifications of the **R-E** Robot, keep in mind that you can build your robot with other components, and in other configurations.

Our robot is powered by two 12-volt lead-acid batteries; it has a top speed of five miles per hour. Although we used utility batteries, we could have used auto or motorcycle batteries. Circuitry that indicates when power is low is included onboard, as is a 117-volt AC battery charger.

The robot's drive system consists of two independent 10.5-inch pneumatic tires that are connected to two toothed belt drives and to two 1/20-horsepower DC torque motors. A caster mounted at the rear provides lateral stability and ease of movement.

The robot is equipped with sensors for measuring temperature, light, and sound.

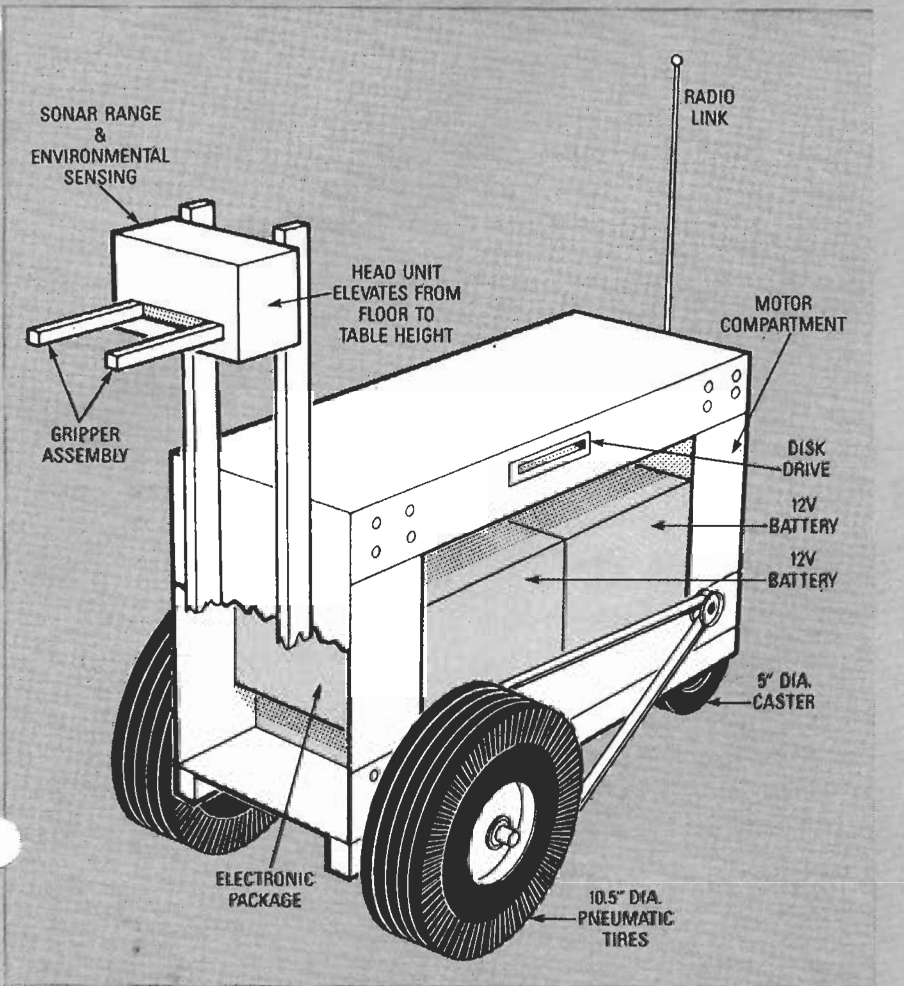

FIG. 1—R-E'S PERSONAL ROBOT has a unique mechanical configuration. This artist's conception shows the overall structure of our prototype. The robot can be modified to suit just about any application.

Microswitch collision detectors and sonar ranging, usable at distances as great as 20 feet, are also provided.

The robot lacks a traditional robot arm. Instead, it features a powerful gripper that rides a vertical track at the front of the unit. The arm, as shown in Fig. 1, somewhat resembles an industrial forklift. While some flexibility is sacrificed using that approach, some important advantages are gained. For one thing, the mechanical design is greatly simplified. That means that greater lifting capacity could be provided without greatly increasing cost. The gripper is capable of vertical travel from floor level to about table height.

In addition, the robot has options for an RF link, a speech synthesizer, and even a speech-recognition system.

e RPC

The hardware that makes it all possible is the RPC (*R*obotic *P*ersonal *C*omputer). The heart of the RPC is a highly integrated Intel 80188 microprocessor; it significantly reduces costs by including—in the IC package—many support devices that are external to the 8088 (used in a true-blue IBM-*PC*). The entire computer occupies a PC board that is less than eight inches on a side.

The interface between the RPC and the I/O unit is an adaptation of the IBM-*PC* bus. Signals from that bus are available at a 60-conductor IDC connector. That bus allows prototype circuits to be built without using special prototype cards.

Control boards

The RPC controls three custom boards. Board 1, shown in Fig. 2, contains most of the basic control circuits; with it and the RPC, the robot is capable of unsupervised operation. Board 1 controls the two torque (drive) motors. Each PWM (*P*ulse-*W*idth *M*odulation) drive-motor controller can deliver as much as 500 watts per wheel. A feedback encoder allows the RPC to keep track of speed and position. Torque load is also monitored.

Other Board-1 functions include gripper-motor control, and control of the sonar ranging system. Based on the Texas Instruments and Polaroid sonar systems, the ranging system can be used for collision avoidance, navigation, and security. Board 1 also contains several miscellaneous systems, including the battery charger, the DC-DC converter, and a beeper alarm. The environmental sensing systems (temperature, light, and sound detectors) are also on Board 1. Last, the collision detector outputs are processed on that board.

The robot differs from many projects presented in **Radio-Electronics** in that it is an evolving project. Many of its circuits are still in the design or testing phase. As a result, some of the final details may differ from those presented here. The other two control boards fall into the still-being-designed category. As of now, Board 2 will contain the speech synthesis and recognition hardware, and that Board 3 will house the RF data link.

Software

Complementing the hardware is a flexible programming environment that allows the programmer to choose his favorite and most productive language. The RPC may be programmed in two different ways.

One approach involves use of either of the onboard languages: BASIC and FORTH. Each language is a combination operating system, development system, and high-level language. Each includes debugging support, inherent ROMability, and access to mass storage, and each supports interrupt programming, integrated procedures, and multitasking. An onboard EPROM programmer allows software to be written, tested, and burned into EPROM for dedicated use.

The other approach makes use of the RPC's IBM-*PC* compatibility. The RPC boots most operating systems designed for the *PC*, thereby allowing the programmer to choose his favorite language. Assembler, Fortran, Pascal, C, BASIC, Compiled BASIC, and many others are all available. Programs in those languages can also be burned into ROM, if the compiler used generates ROMable code. Program code can also remain stored in battery backed-up static RAM for power-on execution. In addition, programs and data can also be stored on floppy disks. The RPC can accommodate any mixture of as many as four 3.5- and 5.25-inch floppy-disk drives.

RCL

Although the robot's software is not yet as extensive as we would like, modules have been written to test each of the robot's capabilities. The next step is an extremely sophisticated *R*obotic *C*ontrol