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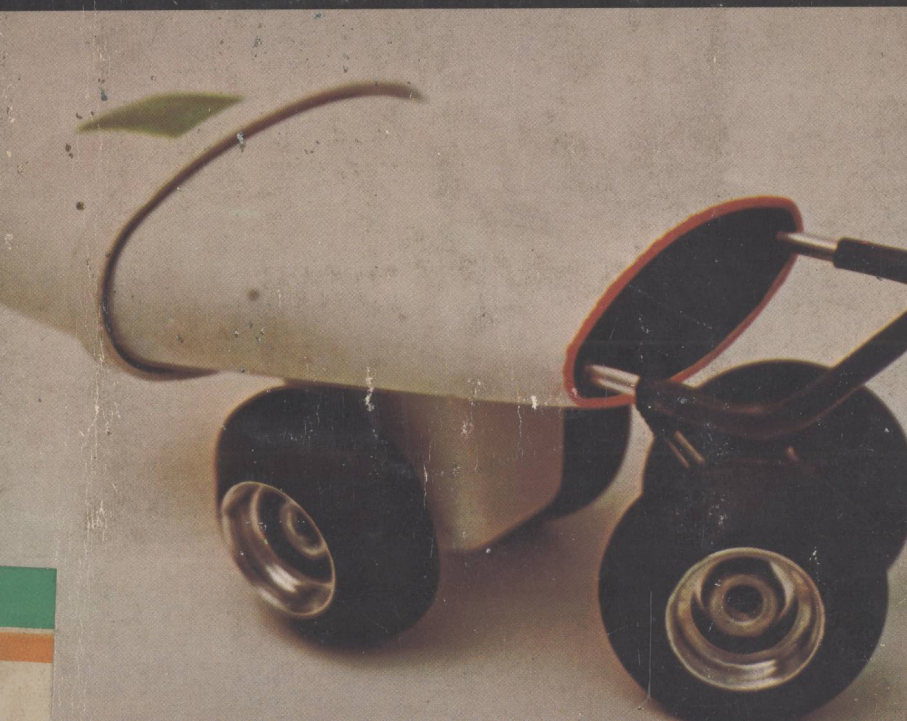
BUILD YOUR OWN WORKING ROBOT

BY DAVID L. HEISERMAN

Step-by-step instructions on how to build a robot with many human characteristics from readily available electronic parts.



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This book is dedicated to my son Paul and his electronic companion, Buster.

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PREFACE

There aren't many books on the subject of robotics, and there are even fewer books telling exactly how to build one in a home workshop. This book is about an unusual robot named Buster, and this little machine has been specifically designed for amateur experimenters who want to try their hand in an infant technology known as *robotics*.

Buster is a true robot. He is not a toy, and he is not one of the fancy remote-controlled props that have been used in popular science fiction TV shows and movies over the past two decades. He is much more than a toy or prop. Buster is more like an animal than a machine—he has some basic reflex mechanisms, a will of his own, and even a personality of sorts. He does not merely mimic animal behavior, either; rather, he is a creature in his own right, and he acts and reacts according to a dynamic programing mechanism that is sensitive to his internal and outside environments.

It is rather difficult to describe exactly what a robot is. The main problem is that there are so many prevailing misconceptions and preconceived notions about what a robot ought to be; and unfortunately, these popular ideas generally expect too little, rather than too much, of the machines. Because there is this need to change many popular ideas, some of the material in this book reads more like philosophy and psychology than electronics. To be sure, the experimenter will

find out how to build Buster for himself, but he will miss an appreciation of what he is really doing if these nontechnical discussions are overlooked or treated lightly.

The experimenter planning to build the Buster system ought to have a background in basic electronics, including a familiarization with TTL technology, transistor amplifiers, and elementary control circuits. A working knowledge of Boolean algebra is also important for understanding and troubleshooting some of the more complex circuits. It is equally important to have mastered some of the basic hands-on skills of electronics, such as making printed-circuit boards.

Building Buster is an ambitious undertaking. There is, however, no need to build the entire system before putting it to work. The book is so planned that an experimenter can build up the system one step at a time, with each step adding a new dimension to Buster's behavior pattern. An experimenter, for instance, might complete only half the work; but even so, he will have a fascinating machine that runs around the floor, poking into corners, and crying woefully whenever his batteries run low. An experimenter, in other words, can do as much of the work as time and finances allow; and if it takes five years to finish the job, so what? He's had a lot of fun working, playing, and observing an example of the highest class of machinery technology can produce today.

I am indebted to a number of individuals who helped with the construction of the prototypes and preparation of the manuscript. A special word of appreciation must go to the Ohio Institute of Technology in Columbus and the many staff members and students who made it possible to engineer, build, and debug the Buster system in such a short time.

Dave Heiserman

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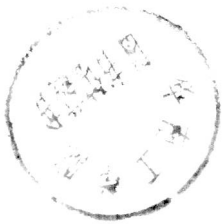

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THE BUSTER CONCEPT

Welcome to the wacky and wonderful world of Buster. It is said that truth can be stranger than fiction, and if that kind of truth has something to do with science, Buster can be seen as something stranger than science fiction. This is not a science fiction book, though—it is a book that describes how to build one of the most unusual machines possible in the context of modern electronic technology.

WHAT IS BUSTER?

Buster is rather hard to describe in a few words. Part of the trouble with trying to describe Buster is that he (or it) is two different things at the same time: he is both a machine and an evolutionary process. What's more, Buster is unique as a machine and quite unusual as a process.

As a machine, Buster represents the highest-order machine that technology can produce today. The lowest-order machine can be represented by simple hand tools such as hammers, screwdrivers, and pliers. The next order then takes the form of slightly more complicated labor-saving devices such as motors and engine-driven vehicles. Basic computer systems represent yet a higher order of machinery—machines that can save humans both mental and physical energy.

Buster is much more than any of these machines. He is much more than a tool, a man-controlled machine, or a

computer system. Buster is a machine that is capable of setting its own goals and achieving them within the limitations of its own logical and physical abilities. And unlike any of the lower classes of machine, Buster can be fully operational without human intervention. Of course Buster can interact with a human operator, provided he doesn't have any other needs that are more urgent at the time. The completed Buster system can, in principle, live a long and active life in the total absence of human company. Lots of simpler machines can run without human intervention, too; but they cannot set their own goals.

Buster is indeed a higher-order machine. The next higher class of machinery is one where the machines are capable of independently producing improved versions of themselves—and neither technology nor human society is ready for that particular class of machinery yet. There are a number of Buster-class machines in various research labs around the world today, and some of them are far more sophisticated than Buster. But the only real difference between Buster and the best robots around is that the more complex robots can do more of the same kinds of things.

One of the essential keys to Buster's unique position in the world of machines is his built-in animal-like reflex system. Every animal has a reflex system of some sort that mainly serves as a mechanism for survival or self-preservation; and most animal behavior is motivated by the needs of survival. Buster has a survival-oriented reflex system; and whenever his energy cells become "hungry," for example, he takes action appropriate for recharging them.

Buster also has a need for activity. His primary goal in life, aside from keeping himself nourished, is to move about. He wanders around for hours on end, poking into corners and running headlong across the floor. If Buster's human doesn't take all the proper precautions, Buster can accidentally disable himself; but as long as the accident isn't one that causes serious physical damage, Buster eventually gets himself out of the predicament or else begins crying for help.

Of what use is Buster? The question is not really appropriate. It's like asking what use is a puppy. Aside from the technical challenge of building such a system, Buster's real "use" lies in playing with him and watching him at work. Buster can be trained to do tricks and fetch a newspaper, but

so can a puppy (and for less money). The motivation for building such a system must come from the experimenter's own constitution—there must be a desire to work first-hand with the highest class of machine available today.

Buster is also a process. Unlike most other electronic projects, the system doesn't have to be complete before he comes alive. Buster evolves stepwise through this book, each step in the process adding more detail to his animal-like behavior.

This evolution-oriented program has the distinct advantage of letting you, the experimenter, reap some of the benefits of your time, labor, and cash outlay long before the program is completed. Once the basic mainframe, power supply, and power control systems are built, you can add whatever functions that time, finances, and moods dictate. And all the while, you'll have a machine that is fun and educational.

SUMMARY OF THE BUSTER PROGRAM

The Buster development program can be divided into three basic phases: *Buster I*, *Buster II*, and *Buster III*. Completing each one of these phases marks a major advance in Buster's modes of behavior; and for the sake of convenience, Buster is named according to his stage of development. Through the first seven chapters, for instance, Buster is called *Buster I*, and then his name changes to *Buster II* as the second phase of the program begins. It is important to understand that *Buster I* is an operational machine that simply lacks some of the finer modes of behavior that characterize *Buster II* and *Buster III*.

The following summary of the Buster development program should be studied carefully at the beginning of the job and every so often along the way. Buster is a big project, and an experimenter can soon lose perspective on where he is going with it. Reviewing this program from time to time gives each new step some additional meaning and it will help keep your thinking channeled in the right direction.

Buster I

Buster I is a wheeled machine that can be driven and steered by means of a simple control panel. *Buster I* can be run forward and in reverse at three different speeds, and

turned left or right at two different steering angles. The control panel is connected to the machine via an umbilical cord.

Buster I phase of the program occupies Chapters 2 through 7. In the first of these chapters, you gather up the materials necessary for building the four-wheel mainframe, power supply, and motors for drive and steering power. The items for carrying out the work of Chapter 2 add up to a considerable cash outlay. The components and equipment specified in this chapter make it the most expensive chapter in the entire Buster program. A suggested temporary control terminal lets you run Buster around the floor via an umbilical cord.

The circuits described in Chapter 3 make the motor control system a bit more elegant. From this point on, Buster is controlled by low-level logic signals rather than brute-force power switching. The optional control terminal used in Chapter 2 can be adapted for this improved version of the *Buster I* model.

Chapter 4 represents the first of many chapters devoted to planning, building, and testing logic control circuits. In this instance, the objective is to add the dimension of speed control to Buster's forward and reverse movements. The temporary control terminal can be modified once again to get the system back into operation.

The first automatic operation enters the system in Chapter 5. The circuit contains the logic and feedback components necessary for steering control; and the most elegant feature of this part of the system is an automatic wheel-centering mechanism—a circuit that automatically centers the steering whenever no turning commands are given. Although the temporary control terminal might be looking a bit ragged around the edges, it can be again modified to suit the new steering scheme.

Chapter 6 is one of the most important chapters in the program, because it marks the point where a growing list of switch controls is suddenly replaced with four simple on/off switches. What is more important is the fact that the circuit transforms Buster into a binary-controlled machine. Anyone unfamiliar with the advantages of binary control might not fully appreciate what is going on at this point in the program; but an effort to learn more about binary logic and controls will pay off in the long run.