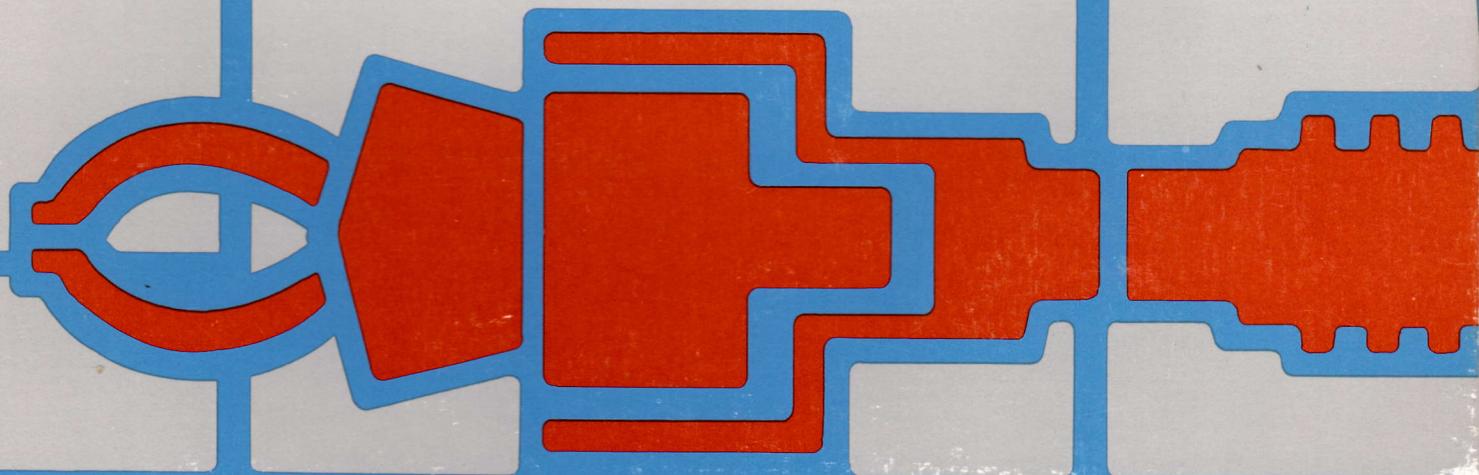


# ET-18 ROBOT USER'S GUIDE



Heathkit



Educational Systems

## HEATH COMPANY PHONE DIRECTORY

The following telephone numbers are direct lines to the departments listed:

Kit orders and delivery information ..... (616) 982-3411  
Credit ..... (616) 982-3561  
Replacement Parts ..... (616) 982-3571

### Technical Assistance Phone Numbers 8:00 A.M. to 4:30 P.M., EST, Weekdays Only

Audio,	.....	(616) 982-3310
Amateur Radio	.....	(616) 982-3296
Test Equipment, Weather Instruments and		
Home Clocks	.....	(616) 982-3315
Television	.....	(616) 982-3307
Aircraft, Marine, Security, Scanners, Automotive,		
Appliances and General Products	.....	(616) 982-3496
Computers — Hardware	.....	(616) 982-3309
Computers — Software:		
Operating Systems, Languages, Utilities	.....	(616) 982-3860
Application Programs	.....	(616) 982-3884

## YOUR HEATHKIT 90-DAY LIMITED WARRANTY

### Consumer Protection Plan for Heathkit Consumer Products

Welcome to the Heath family. We believe you will enjoy assembling your kit and will be pleased with its performance. Please read this Consumer Protection Plan carefully. It is a "LIMITED WARRANTY" as defined in the U.S. Consumer Product Warranty and Federal Trade Commission Improvement Act. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

#### Heath's Responsibility

**PARTS** — Replacements for factory defective parts will be supplied free for 90 days from date of purchase. Replacement parts are warranted for the remaining portion of the original warranty period. You can obtain warranty parts direct from Heath Company by writing or telephoning us at (616) 982-3571. And we will pay shipping charges to get those parts to you . . . anywhere in the world.

**SERVICE LABOR** — For a period of 90 days from the date of purchase, any malfunction caused by defective parts or error in design will be corrected at no charge to you. You must deliver the unit at your expense to the Heath factory, any Heath/Zenith Computers and Electronics center (units of Veritechnology Electronics Corporation), or any of our authorized overseas distributors.

**TECHNICAL CONSULTATION** — You will receive free consultation on any problem you might encounter in the assembly or use of your Heathkit product. Just drop us a line or give us a call. Sorry, we cannot accept collect calls.

**NOT COVERED** — The correction of assembly errors, adjustments, calibration, and damage due to misuse, abuse, or negligence are not covered by the warranty. Use of corrosive solder and/or the unauthorized modification of the product or of any furnished component will void this warranty in its entirety. This warranty does not include reimbursement for inconvenience, loss of use, customer assembly, set-up time, or unauthorized service.

This warranty covers only Heath products and is not extended to other equipment or components that a customer uses in conjunction with our products.

**SUCH REPAIR AND REPLACEMENT SHALL BE THE SOLE REMEDY OF THE CUSTOMER AND THERE SHALL BE NO LIABILITY ON THE PART OF HEATH FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCLUDING BUT NOT LIMITED TO ANY LOSS OF BUSINESS OR PROFITS, WHETHER OR NOT FORESEEABLE.**

Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

#### Owner's Responsibility

**EFFECTIVE WARRANTY DATE** — Warranty begins on the date of first consumer purchase. You must supply a copy of your proof of purchase when you request warranty service or parts.

**ASSEMBLY** — Before seeking warranty service, you should complete the assembly by carefully following the manual instructions. Heathkit service agencies cannot complete assembly and adjustments that are customer's responsibility.

**ACCESSORY EQUIPMENT** — Performance malfunctions involving other non-Heath accessory equipment, (antennas, audio components, computer peripherals and software, etc.) are not covered by this warranty and are the owner's responsibility.

**SHIPPING UNITS** — Follow the packing instructions published in the assembly manuals. Damage due to inadequate packing cannot be repaired under warranty.

If you are not satisfied with our service (warranty or otherwise) or our products, write directly to our Director of Customer Service, Heath Company, Benton Harbor MI 49022. He will make certain your problems receive immediate, personal attention.

# **HERO ROBOT**

Model ET-18

595-3070-01

HEATH COMPANY  
BENTON HARBOR, MICHIGAN 49022

Copyright © 1983  
Heath Company  
*All Rights Reserved*  
Printed in the United States of America

## TABLE OF CONTENTS

WARNING .....	3	PROGRAMMING FROM THE KEYBOARD .....	25
INTRODUCTION .....	4	The Program Mode and The Repeat Mode .....	25
Factory Assembled Units .....	4	Memory Considerations .....	25
Your Robot .....	4	Entering A Program .....	26
BASIC INFORMATION .....	5	Checking/Changing A Program .....	26
Removing The Head Panel .....	5	Running A Program .....	27
Installing/Removing The Body Panels .....	6	Program Example .....	27
Setting Wrist Rotation .....	7		
Mounting and Adjusting the Arm .....	9	MAKING THE ROBOT TALK .....	30
Installing or Replacing Batteries .....	9	Programming The Words .....	30
Battery Usage .....	10	Phoneme Notes .....	32
Turning Your Robot On For The First Time .....	12	Playing Back A Speech Program .....	32
CARE AND MAINTENANCE .....	13	Programming Inflection .....	33
THE KEYS AND THE DISPLAY .....	14	Adjustments .....	34
The Keys .....	14	Speech And Inflection Examples .....	34
The Display .....	15	Special Phrases In Permanent Memory ....	38
MODES OF OPERATION .....	17		
Utility Mode (3) .....	17	USING THE ROBOT SENSES .....	39
Executive Mode (RESET) .....	21	Time .....	39
Manual Mode (4) .....	21	Light .....	40
Learn Mode (7) .....	23	Sound .....	41
Repeat Mode (A) .....	24	Motion .....	42
		Ultrasonic Ranging .....	43
		MORE COMPLEX OPERATIONS .....	44
		Sleep Operation .....	44
		Simultaneous Operations .....	44
		Programming Possibilities .....	44
		The Experimental Board .....	45
		INDEX .....	47

## WARNING

This equipment has been verified to comply with the limits for a Class B computing device, pursuant to Subpart J of part 15 of FCC Rules.

This equipment generates and uses radio frequency energy for its operation and if not installed and used properly, that is, in strict accordance with the instruction manual, may cause interference to radio and television reception. It has been type tested and found to comply with the RF emission limits for a Class B computing device which is intended to provide reasonable protection against such interference in a residential installation. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Move the equipment away from the receiver being interfered with.
- Relocate the equipment with respect to the receiver.
- Reorient the receiving antenna.

If additional help is needed, consult the dealer or ask for assistance from the manufacturer. Customer service information may be found on the inside back cover of this manual or on an insert sheet supplied with this equipment. The user may also find the following booklet helpful: "How to Identify and Resolve Radio-TV Interference Problems." This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20402. — Stock No. 004-000-00345-4.

## INTRODUCTION

### FACTORY ASSEMBLED UNITS

If you have a factory assembled Hero, you will need to insert batteries, install the arm, and mount the body panels before you use your Robot. These items were packed separately to avoid damage and the delays that repair or replacement can cause. Go to "Basic Information," Page 5, for the battery, arm, and panel instructions.

**NOTE:** You may wish to save the box and packing that contained the arm and control handle. You could use it if you should ever have to return the arm, control, or any circuit boards for service.

### YOUR ROBOT

Your Robot (shown in Figure 1 Illustration Booklet, Page 1) has a computer built into it. It has a keyboard that you can use to program it, memory to store the programs, and a display to show what information it has stored. But your Robot is more than just a computer. It can sense light, sound, and motion. It can use its ultrasonic detector to sense obstructions. It can speak\*. It can move itself, and pick up small objects with its arm\*. It can learn the movements you teach it, and repeat them on command.

Briefly, here is how the Robot operates. Its computer has a 6808 microprocessor, permanent memory, and temporary memory. The microprocessor has a small number of built-in commands that it recognizes. In addition, the permanent memory allows it to recognize a few more commands that apply to Robot operations.

The computer is connected to the keyboard, to each of the senses, and to each of the motors. In this way, it can send to, or receive from, any one device at a time as part of its operation. Since it operates so fast, it can appear to do more than one thing at a time, such as checking the keyboard, checking the light sensor, sending power to the head motor, and repeating the cycle tens of thousands of times in one second.

Once you have mastered the basics of operation, you may choose to refer to the Technical Manual to learn more complex programming. With the proper skills, you can program the Robot to:

- Find its way out of a maze, or through a crowded room.
- Point out a light that's "too bright," and ask you to turn it off.
- Stand guard at night, and warn if it detects an intruder.

You can also use the Robot's computer-controlled abilities in some other new and creative ways, but to do this, you must first learn about each of the abilities separately. This learning is the main purpose of the User's Manual. After mastering these basics, you can proceed to the Technical Manual, for detailed information on the Robot's electronics and the complexities of computer language programming. Finally, you may wish to purchase the Heath educational course on industrial robotics (EE-1800) dealing with the generalities of robots and their operation.

\*Optional

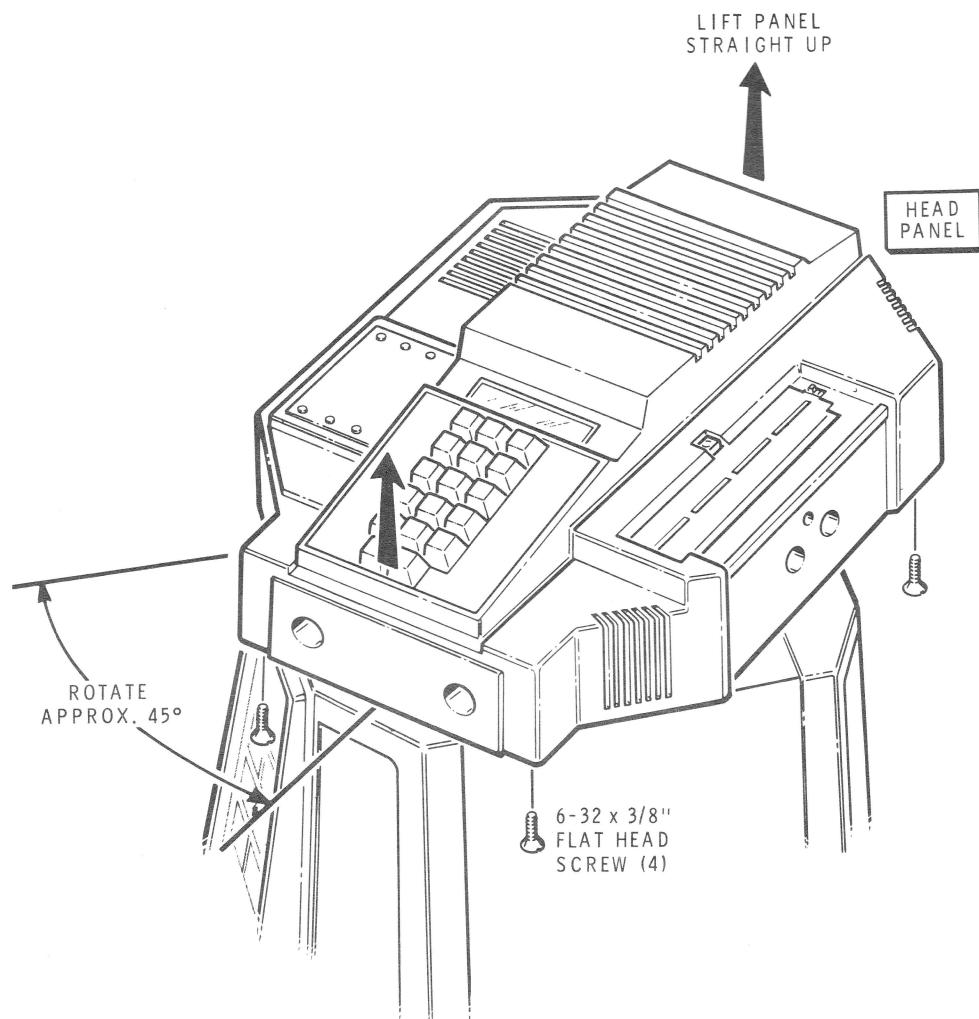
## BASIC INFORMATION

This portion of the Manual contains information that will be useful if you need to do any elementary service to the Robot. Save this Manual and refer to this section when you need it. However, if you are the new owner of a factory-built Robot, you will need this information now, to install the batteries, attach the arm, and mount the body panels. More detailed technical information about Robot circuitry is in the Technical Manual.

### REMOVING THE HEAD PANEL

The head panel is held in place with four 6-32 × 3/8" flat head screws. To remove these screws, rotate the head (by hand) to the position shown in Figure 2. In this position you have access to all four of the screws (even if the body panels are in place). Remove them and lift the head panel straight up by the sides. You can mount the arm and head battery only with the head panel removed.

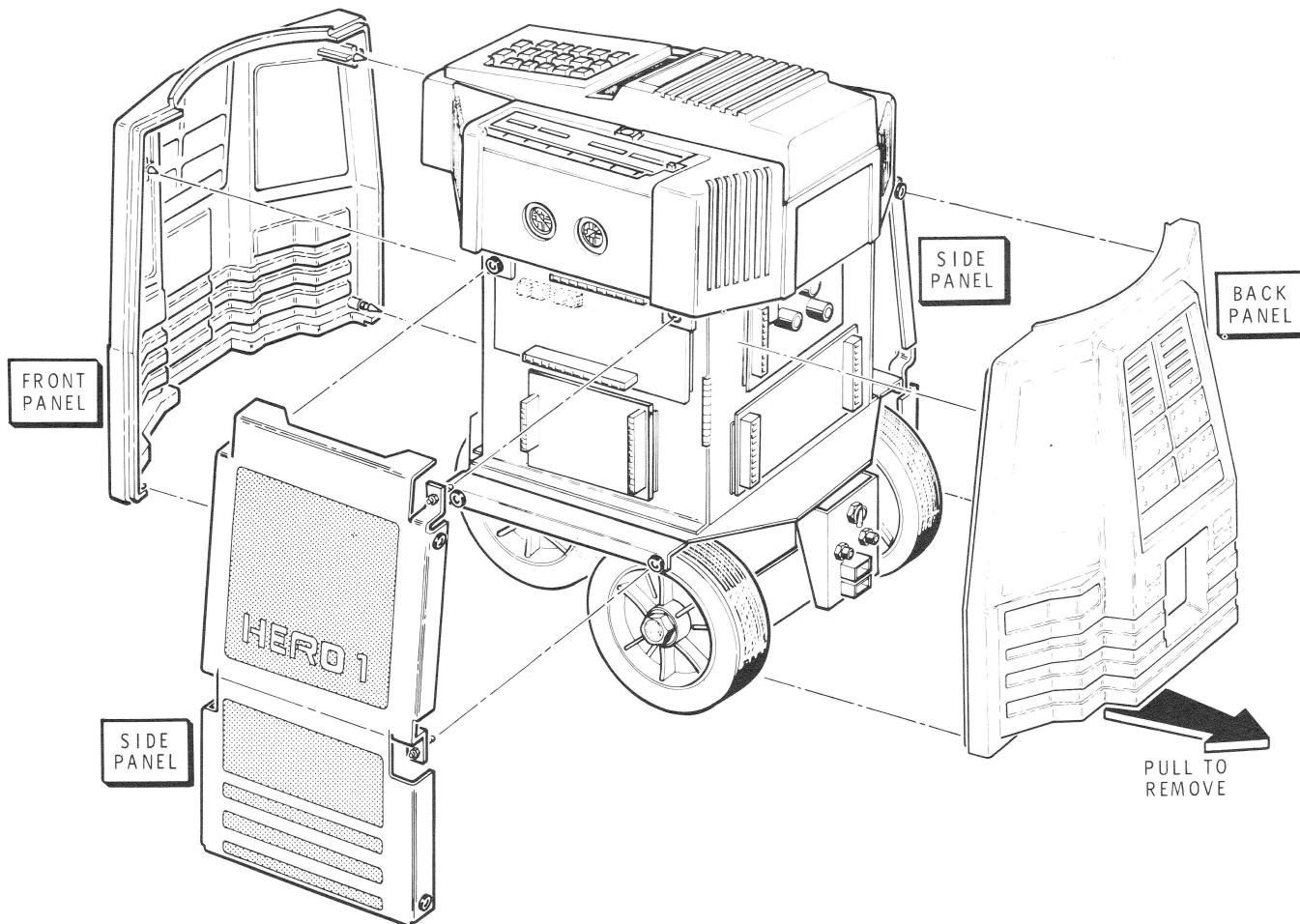
To replace the panel, reverse the procedure.



**FIGURE 2**

**INSTALLING/REMOVING THE BODY PANELS**

You should remove the body panels when you install or replace the three batteries in the base of the Robot. To install the body panels, simply press them into place as shown in Figure 3. The metal side panels go into place first; simply align the metal pegs with the rubber grommets and press the panels firmly into place. Then install the plastic front and back panels in a similar manner. To remove the panels, start with the plastic front and back panels, and pull gently at the base.

**FIGURE 3**

# Heathkit®

---

## SETTING WRIST ROTATION

When the arm extends, it can rotate the entire wrist assembly 90 degrees during the last 2 inches of extension. This rotation is mechanical, and cannot be controlled electronically.

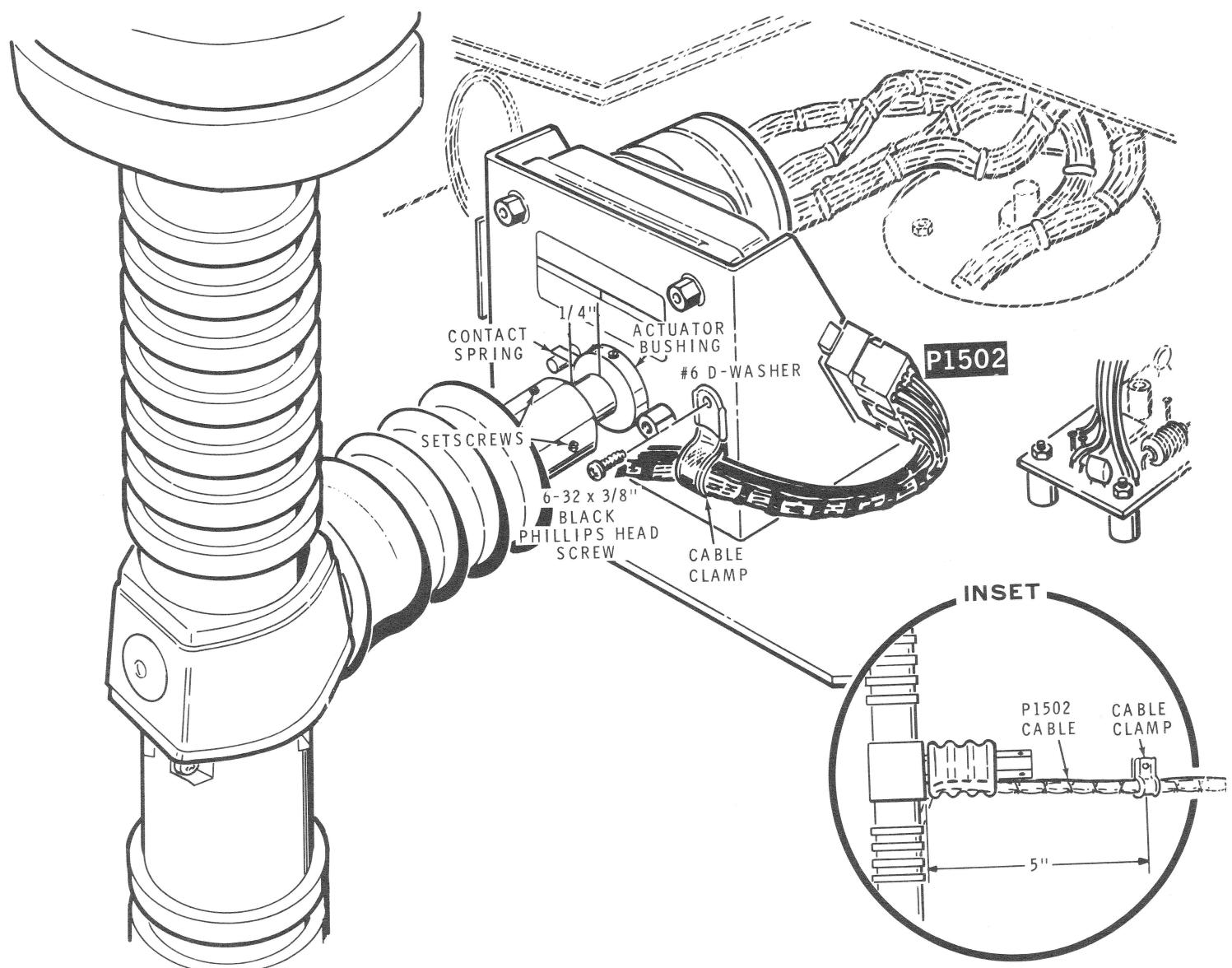
The factory-assembled Robot includes this extend-rotation, to give more mobility. However, you may wish to remove this action, since it makes some carrying and picking up with the gripper more difficult (the gripper changes orientation when the arm extends).

You can change the arm action between "rotating" and "nonrotating" in your Robot by reversing the position of the two arm shells. To do this, refer to Figure 4 (Illustration Booklet, Page 1) and follow these instructions:

- If the arm is mounted on the Robot, reverse the instructions in the next section, "Mounting The Arm," and dismount the arm.
- Lay the arm on a flat surface, and remove the seven 6-32 × 3/8" black phillips head screws and nuts from the arm shells.
- The shells have a shoulder plug, shoulder bushing, and motor bracket slots that help keep them aligned and held together. Remove the top shell by carefully working it straight away from the lower section, at these slots.

- In the same manner remove the bottom shell and the shoulder plug from the slot in the arm shell it occupies.
- To reverse the two shells, put the (formerly top) shell in place under the arm assembly. To it, add the shoulder bushing and shoulder plug in their slots, and the motor bracket in its slot. Then carefully place the motor assembly leads in the groove as shown.
- Note the track inside the remaining arm shell. The 1/4" bushing on the arm must fit into this track. For a "rotating" arm, this track should have a curve as shown in the inset drawing; if you want a "non-rotating" arm, the track should be straight.
- Position the arm shell loosely in place. Make sure the motor leads are in their groove and will not be pinched. Install one of the 6-32 × 3/8" screws at the wrist, as shown, to hold the wrist cord retainer.
- Use the 6-32 × 3/8" hardware to secure the shells together.

The arm rotation is now properly set. Proceed to the section titled "Mounting The Arm."

**FIGURE 5**

**MOUNTING AND ADJUSTING THE ARM**

The arm mounts on the shaft extending from the bracket at the back of the head. The head panel must be off to mount the arm. Refer to Figure 5 for the following steps.

- Remove the cable clamp and D-washer from the bracket and place the clamp on the arm cable, 5" from the arm body. See the Inset drawing in Figure 5.
- Loosen the setscrew in the actuator bushing so the bushing turns freely on the motor shaft.
- Loosen the setscrews in the arm, if necessary, and slide the arm onto the shaft. Then, turn the arm clockwise until the gripper is straight up.
- Reinstall the cable clamp and D-washer; then plug in connector P1502. Note the position of the ridges in the two connectors.
- Slide the arm outward until you can see the flat on the motor shaft. Then turn the arm counterclockwise until either setscrew is over the flat.
- Slide the arm onto the shaft until about 5/16" of shaft is exposed and tighten the setscrew onto the flat. Then tighten the other setscrew.
- Note the position of the arm and rotate the actuator bushing so its spring contact is at a right angle (90°) to the arm. Then tighten the setscrew in the actuator bushing.

**CAUTION:** Do not attempt to manually rotate the arm after it is secured to the shoulder motor shaft. Damage to the arm is sure to result.

If, after you "initialize" the Robot later in this Manual, you find the arm is not in the down position, you can readjust it by loosening the actuator bushing, moving the arm to the desired position, and retighten the actuator spring against the contact post.

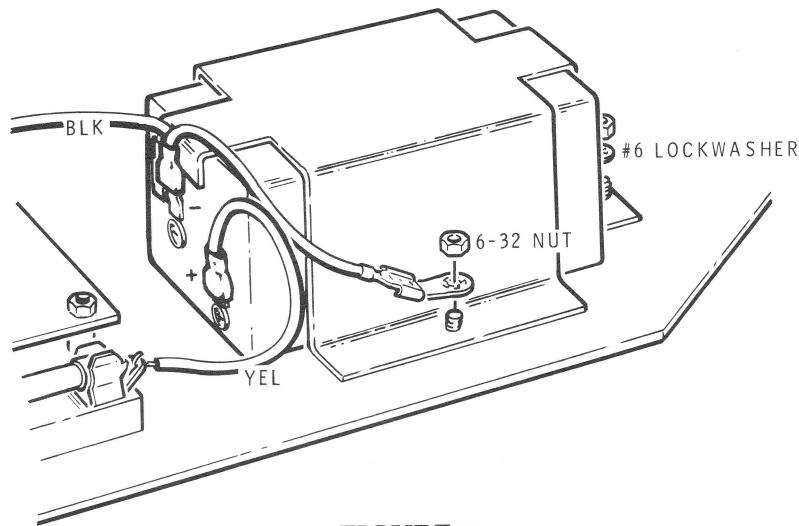
This completes the mounting and adjusting of the arm.

**INSTALLING OR REPLACING BATTERIES****Batteries in Base**

Refer to Figure 6 (Illustration Booklet, Page 2) for the following steps. The body panels must be off to install the batteries.

- Remove the plate at the lower back of the Robot, if it is in place. You can use the nutdriver to help remove the four 6-32 nuts.
  - Refer to the Figure and position three batteries next to the base.
- WARNING:** Do not let the battery terminals touch any bare metal or wire. This could cause a short, ruining the battery and possibly welding it to the metal.
- Connect the wires from the Robot to the batteries. Make sure you have the correct color wires connected to the + and - battery terminals. The 4" large red wire is shipped as part of the wiring harness in the wired Robot.
  - Carefully slide the two batteries (B1 and B2) that are connected together up into the battery bracket. The area above the batteries has insulating paper applied, so you do not have to worry about shorting the battery terminals against it.
  - Place the third battery (B3) in the battery bracket.
  - Replace the plate across the back of the battery bracket and reinstall the hardware.

This completes the installation of the base batteries.

**FIGURE 7**

### Battery in Head

Refer to Figure 7 for the following steps.

- Remove the battery bracket from your unit by removing the two 6-32 nuts.
- Install the battery and bracket, with the lockwashers positioned as shown. Push-on lugs are used for connection to the battery terminals. The yellow wire connects to the positive (+) battery terminal, and the black wire connects to the negative (-) terminal and the bracket stud.

### BATTERY USAGE

The Robot can operate on its batteries, or while it is connected to its charger. With batteries, it will, of course, have some limit to how long it can run.

The batteries are connected in two pairs, with each pair supplying 12 volts to part of the system, as shown in Figure 8. One set (the "drive" batteries) powers the Robot's motors, while the other set ("logic") powers the senses, programming, and logic electronics.

The drive batteries could discharge within an hour if the different motors are run continuously; the logic batteries should last longer, even under the most trying circumstances. Remember, however, that you are using the logic batteries **whenever** the Robot is ON.

Low logic and low drive conditions are treated differently by the Robot. If the drive voltage goes below 10 volts, the Robot will stop and the display will show "drLo." The Robot will not move until you acknowledge the low drive condition by pressing any of the keys on the keyboard.

If the logic voltage goes below 10 volts, the Robot will stop and the display will show "LGLo," and the Robot will say "low voltage" if it has the speech option. The Robot will not move, and will continue to say "low voltage" every 10 seconds until you acknowledge the condition by pressing any of the keys on the keyboard. If the Sleep Switch is on, the Robot will indicate the low condition, sleep 30 seconds, then continue to repeat the cycle. You must acknowledge during the interval while the Robot is "awake."

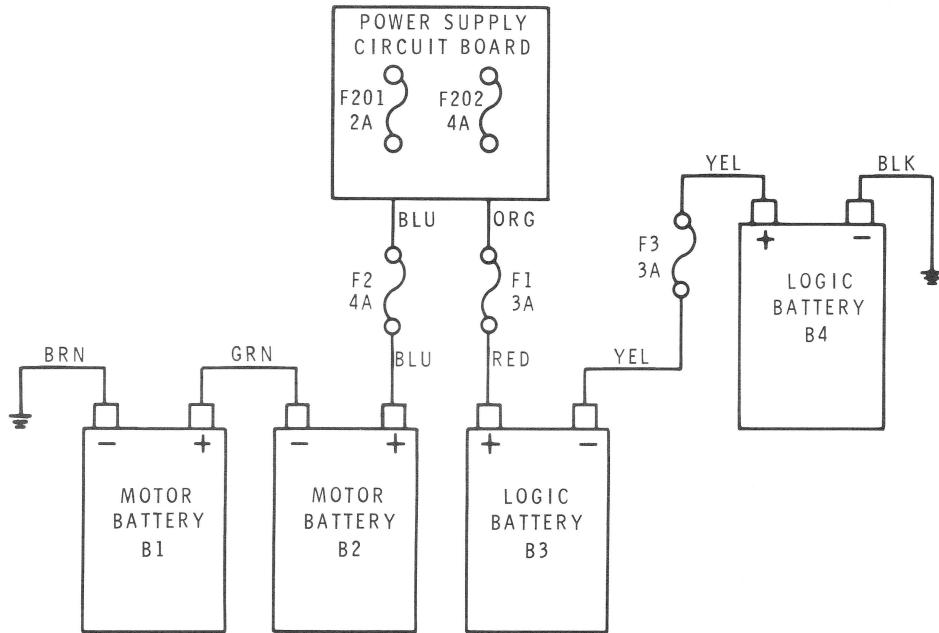


FIGURE 8

After you acknowledge either of the low voltage conditions, the Robot will return to normal operation. It will not remind you of the low voltage, unless you press Reset or turn the Robot off and on again, so you must remember to recharge the batteries. **WARNING:** If the logic voltage gets low enough, the computer may start to send false operating instructions to the motors; your Robot could suddenly take off in high gear. Because of this, you should recharge the batteries soon after getting the low voltage indication.

A fully discharged battery set can be recharged in 8 to 10 hours, using the charger. You do not have to worry about overcharging the batteries; you can leave the charger on continuously if you wish. However, do not leave the charger connected to the Robot with the charger turned off (or unplugged from the wall socket). If the charger is off, it can draw a small amount of current from the batteries and eventually discharge them.

If you leave the Robot alone for long periods of time, you should recharge the batteries every six months.

## TURNING YOUR ROBOT ON FOR THE FIRST TIME

If you have a factory assembled Robot, use this section of the Manual as a guide when you turn the Robot on for the first time. But before you begin here, make sure you have completed the previous sections of the "Basic Information" section.

Refer again to Figure 1, Illustration Booklet Page 1, to see the devices and connectors that are referred to in the following paragraphs. Also refer to the "Care and Maintenance" section of this Manual to avoid damaging any parts of the Robot.

Now that you have installed the arm and the batteries, you must charge the batteries. First, plug the Charger's line cord into a standard 120 volt household outlet (do not connect the other connector to the Robot yet). Turn the Charger on, and its red light will glow. Make sure the Robot's Power switch (shown in the inset drawing of Figure 1) is turned off. Then connect the Charger's output connector to the "Charger" socket at the rear of the Robot base. The white charger light will glow, showing that current is going to the Robot batteries. The brightness of the white light shows how much current the Robot is taking.

You must charge the batteries for about eight hours before you can run the Robot without the Charger connected. However, you can run the Robot immediately with the Charger connected. This will allow you to verify that both the Robot and the Charger work. But before you turn the Robot on, make sure that the Sleep switch (shown on the head, in Figure 1) is in the NORMAL position. If the Sleep switch is in the SLEEP position, the Robot will not turn on properly.

Move the Robot's Power switch to ON. The Robot should say "ready" and show "HEro1.X" on the display. This will use some power and the Charger's white light will probably glow a little more brightly. After about 15 seconds, the display should change from "HEro1.X" to a single dash which moves back and forth across the display face.

Continue to charge your Robot's batteries while you go on to read the next sections of this Manual. The Robot itself may be left either on or off as long as the Charger is on. You will begin to operate your Robot as soon as you reach the "Modes of Operation" portion of this Manual.

**NOTE:** Straight ahead travel of the Robot is determined by the position of an adjustable spring on the drive wheel bracket. This spring may become misadjusted during shipping and/or unpacking. If during the initial checkout of your Robot you notice that it does not travel reasonably straight, perform the readjustment as it is described on Page 51 of your Technical Manual.

## CARE AND MAINTENANCE

The Hero Robot is intended for use in normal indoor domestic environments. With the Hero, just as with any other fine electronic device, you should avoid placing your Robot in atmospheres that are dusty, wet, or caustic. Like other microprocessor-controlled devices, the Robot can be "confused" by static electricity. Avoid subjecting it to static shocks.

In addition, protect the Robot from mechanical damage; operate it on an even surface where it will not tip or fall, keep it away from mud, water, and rocks. For smoothest operation, use your Robot on smooth floors (tile, linoleum, hardwood, or short-pile carpets). Shag carpets make it hard for the Robot to roll, and the carpet threads can get caught in the Robot's undercarriage.

You may clean the exterior and any exposed parts of the drive mechanism by wiping them with a slightly damp cloth, or using a vacuum with a dusting attachment. Never spray water on the Robot.

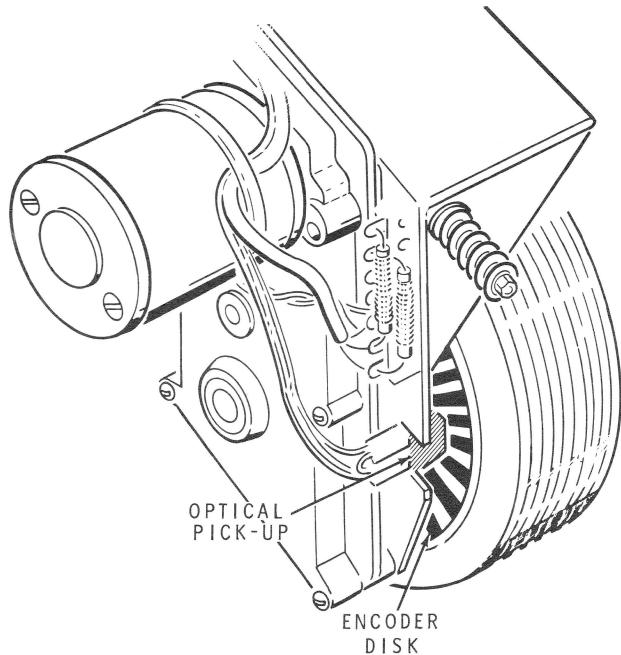
The four rechargeable batteries should provide many hours of enjoyable Robot operation, under normal environment and use. If you see any leakage or strange deposits near a battery, investigate immediately. If a

battery is damaged, replace it only with an exact replacement from Heath Company. If you ever need to replace batteries, refer to the instructions in the "Basic Information" section of this Manual.

All motors and gearcases in the Robot are permanently lubricated. They should require no additional oil or grease over the life of the product. Keep all areas of mechanical operation free of dust or other abrasive material.

Occasionally, wipe the disk attached to the front wheel, and the optical pickup for it. See Figure 9 for the location of these components.

Two devices are connected to the Robot with a cord, the Charger and teaching pendant. Treat them with the same care you reserve for the Robot. Always grasp the plug or connector itself to disconnect a cord, do not pull on the cord. Do not allow the Robot to run past the cords' reach and pull the Charger to the floor. Do not allow cords to become twisted by letting the Robot turn continuously in one direction. Finally, provide adequate ventilation space for the Charger and keep bits of wire or other metal out of the Charger's ventilated case.



**FIGURE 9**

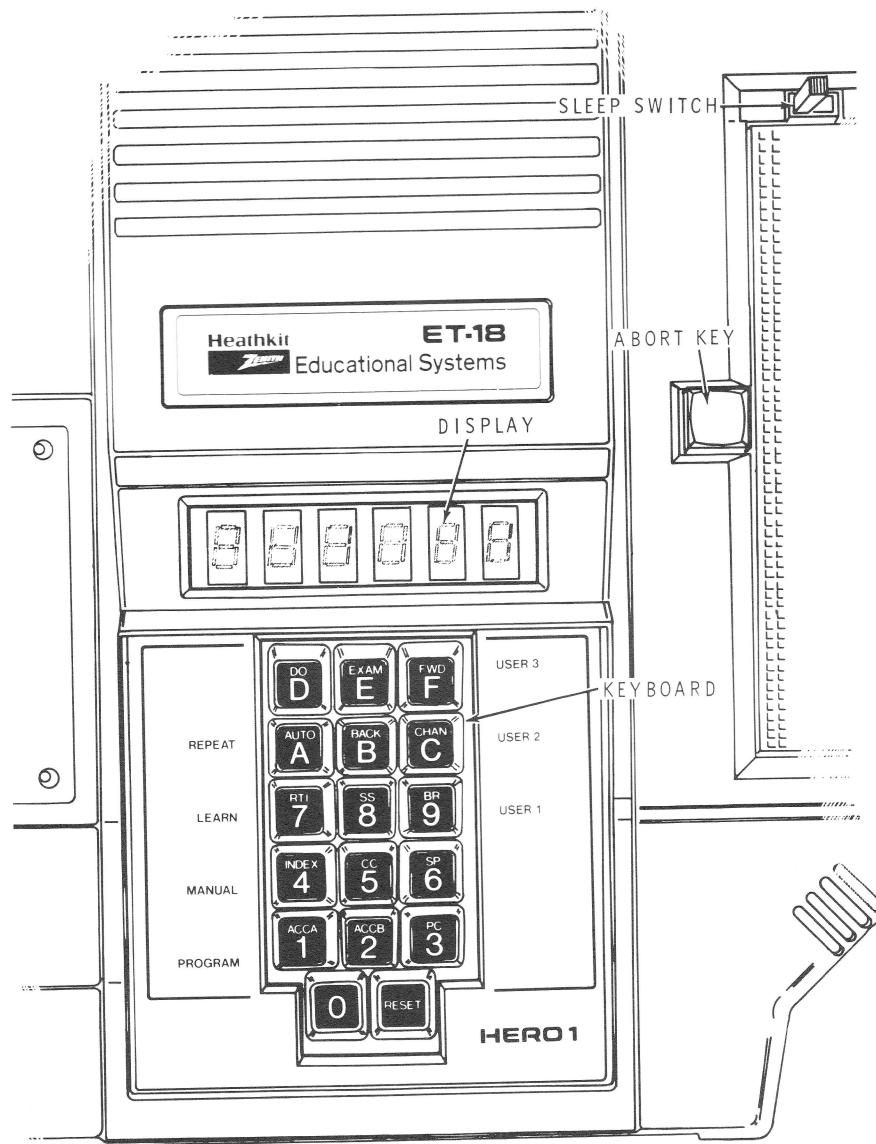
## THE KEYS AND THE DISPLAY

### THE KEYS

The keys are your main method of communicating with the Robot's computer. Some keys have a single purpose; others can serve more than one purpose, depending upon what conditions exist when a key is pressed. Figure 10 shows all of the keys discussed here.

### The Zero and RESET Keys

These are single-purpose keys. The 0 key is only used as the number zero. This is for keying in commands, data, or memory address numbers. The RESET key always calls your Robot's computer back to a sort of beginning point (called the Executive Mode), ready to enter the various operating modes (in response to other keys being pushed).



**FIGURE 10**

# Heathkit®

---

## The ABORT Key

The third single-purpose key is the ABORT key, located on the experimental circuit board. You can use it in case the Robot begins doing something wrong or unexpected. When you press this key, the computer will stop whatever it is doing, without actually changing the program that it was running on. The Robot will stop moving, talking, sensing, or computing. The display will show the word "abort" for about 1 second, and will then display the contents of the computer's program counter. This usually represents the address of the last executable command the computer saw before the abort button was pressed. Experienced programmers can use this address when "debugging" the Robot's program.

## The SLEEP Switch

The Sleep switch is a slide switch, not a key, but it serves much the same function as the keys. This switch (in the SLEEP position) programs the Robot's computer to enter the sleep operation in response to a command in a program or a RESET command from the keyboard. NOTE: If the switch is in the SLEEP position and you press the RESET key or turn the Robot on, the Robot will go to sleep. It will behave as though it were turned off. To return the Robot to normal operation, simply move the Sleep switch to the NORMAL position. The Robot will turn on within 10 seconds.

## Multipurpose Keys

The remaining keys are all multipurpose keys. One purpose they fill is to represent numbers for programming the computer. They represent the numbers 0 through F (the hexadecimal number system is used, with the "numbers" A, B, C, D, E, and F following the number 9). These numbers are used to represent instructions or data while entering actual programs.

Since the numbers are only needed for programming, the keys can serve other purposes when not being used for programming. The computer has a number

of "modes" of operation (such as programming, manual control from the pendant, learning from the pendant, repeating what was learned, etc.). You can initiate each of these modes by pressing the proper key. The most important basic keyed modes are those that follow. If the computer is in the Executive Mode (the starting place to go to all the other modes), when you press these keys, the computer will change modes. The different modes are discussed after this section.

**Key 1** — If you press the **1**, the computer will change to the Program Mode.

**Key 3** — If you press the **3**, the computer will change to the Utility Mode.

**Key 4** — If you press the **4**, the computer will change to the Manual Mode.

**Key 7** — If you press the **7**, the computer will change to the Learn Mode.

**Key A** — If you press the **A**, the computer will change to the Repeat Mode.

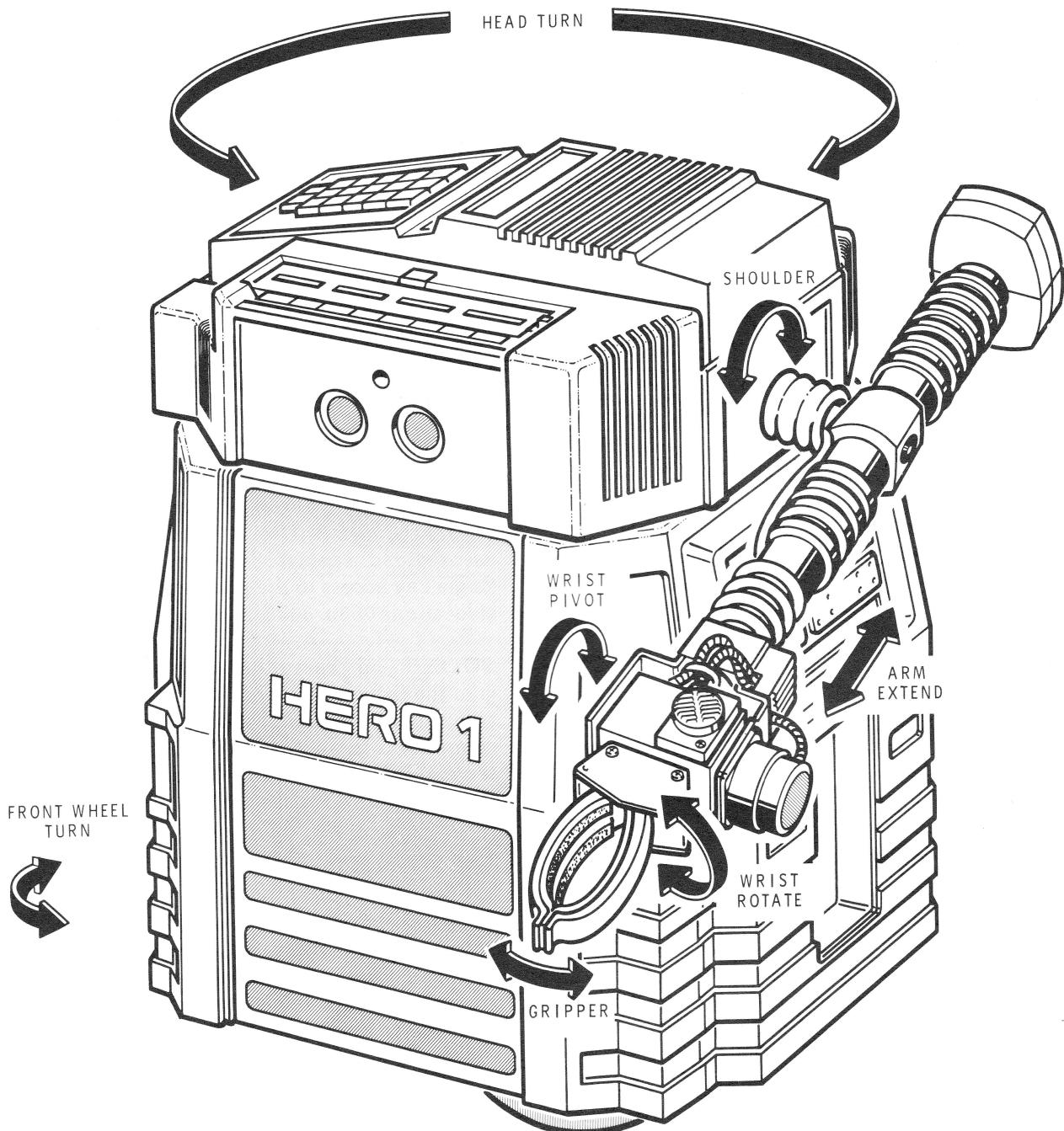
Keys 9, C, and F (User 1, User 2, and User 3) are user-defined special purpose keys. They permit single-key access to the programs that may be stored at locations 0030, 0033, and 0036 respectively.

NOTE: If you press other keys while the computer is in the Executive Mode, it will not recognize them as acceptable inputs. If you press any key while the computer is in another mode, the key will probably serve a different function. These more complex key operations are discussed in the Technical Manual.

## THE DISPLAY

Just as the keys are your way of talking to the computer, the display is its way of talking to you. As you become more knowledgeable about programming, you will read the display to examine and correct the programs in the Robot, examine information from the sensors, and verify what mode you are in.

The Mode and Programming discussions in this Manual, and appropriate sections in the Technical Manual, will tell you what to expect from the display, and how to use the information in the display.

**FIGURE 11**

## MODES OF OPERATION

Each of the various families or types of operation is called a mode. The following is meant to familiarize you with the basic information about each mode. The heading for each mode indicates in parentheses which key to press, if you wish to enter that mode.

### UTILITY MODE (3)

The Utility Mode is like any other "utility." It provides services that you will want or need during daily operation. You enter the Utility Mode by pressing **3**. Pressing a second number selects the specific utility you need.

#### Initializing (31)

Initializing is an important utility. It places the drive wheel in the "straight" position, and the head, arm, wrist, etc., in their "home" positions, so the computer knows their location. Unless you have manually moved the head or drive wheel after turning off your Robot, you need not initialize each time you turn it on. However, you should re-initialize after long periods of non-use to be sure all "home" positions are registered in the Robot's Memory. Initialize the Robot from the Utility Mode by pressing a **1** (press **31** when starting from the Executive Mode).

When you initialize the Robot, the following things will happen (see Figure 11):

1. The Arm Extend\* will go to the fully "in" limit.
2. The Shoulder\* will go to the fully down limit.
3. The Wrist Rotate\* will turn to the fully counterclockwise limit (as viewed from the front).

4. The Wrist Pivot\* will turn all the way up (to the Robot's left).
5. The Gripper\* will go to the fully closed limit.
6. The Head will turn counterclockwise (from the top) to its limit.
7. The Front Wheel will turn to the left to its limit.
8. The Wrist Rotate\* will return to its center position.
9. The Head will return to its center position.
10. The Front Wheel will return to its center position.
11. Then the computer will return to the Executive Mode.

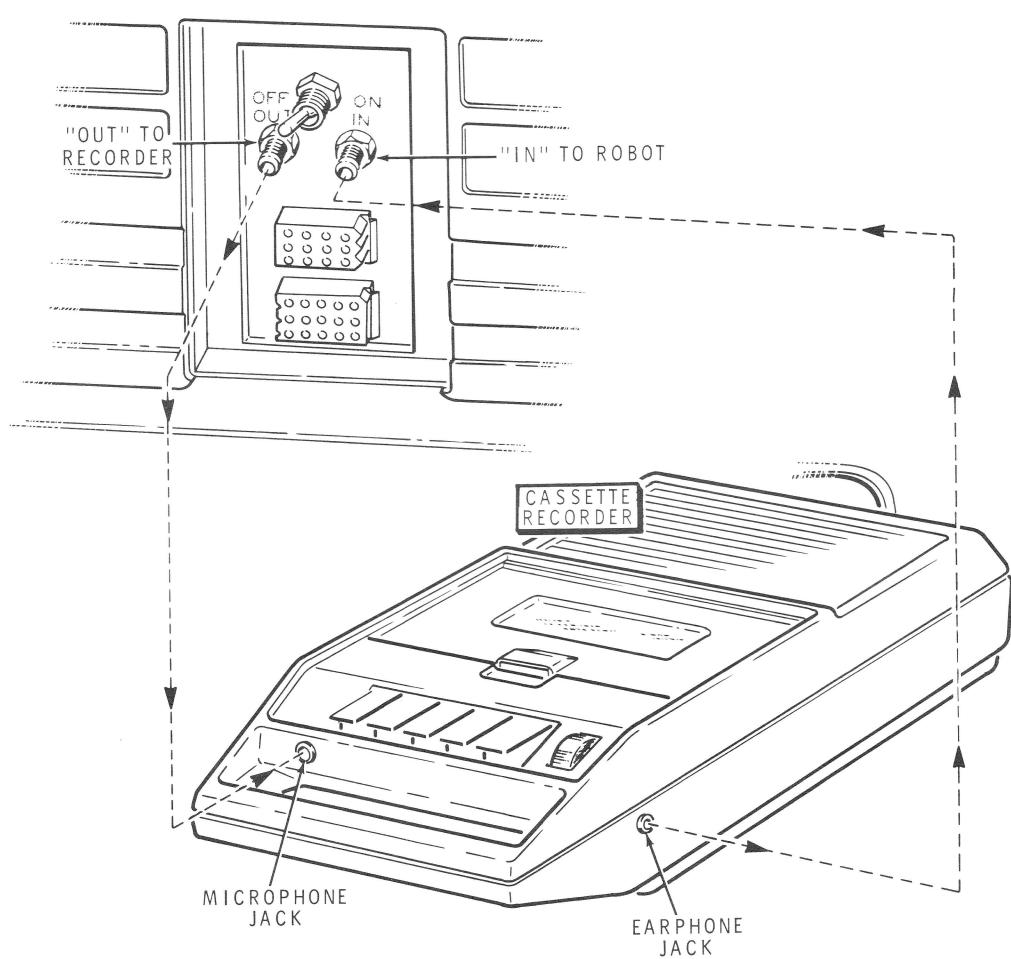
If some force should move one of the mechanical components from its initialized position, the Robot will not know this and will not correct for it. For example, the front wheel might get pushed slightly crooked while operating. Then the Robot will literally go in circles, until you reinitialize it. Then the proper "straight ahead" will be reassumed.

#### Arm Homing (32)

A second "homing" command exists in the Utility Mode. If a program has left the arm, head, or steering in any position other than the normal "home" position set by the initialize utility, the "homing" utility will return arm, head, and steering to the home position.

Enter the homing utility by entering **3** (utilities) and **2** (homing).

\*If you do not have the arm option, the Robot will sit still during the time allotted for these actions.

**FIGURE 12**

# Heathkit®

---

## Download To Cassette (33)

This utility is very useful if you have large programs that you wish to save. You can save these programs on almost any cassette recorder, just as computer enthusiasts do. To save a Robot program on cassette (refer to Figure 12):

1. Connect a cable (provided) from the Robot's output on the back panel to your cassette recorder's input connector.
2. Press **3** (utilities) and **3** (download) on the keyboard.
3. The display will show **---Fr**. Enter the memory address of the beginning of the program you want to save.
4. Use the digital counter on your recorder to tell where the program will be recorded on the tape. Then start your cassette recorder, recording the input.
5. The Robot display will show **---La**. Immediately enter the address of the last piece of program.
6. The program will download to the recorder. When the program is completely recorded, the Robot will automatically go to the Executive Mode, and will say "ready," if you have the voice option.

Let the recorder run to put some blank space on the tape before you record another program. You may choose to go to the next multiple of 10 on the recorder's digital counter. This makes it easier to find the different programs when uploading from cassette to Robot. Keep a card with the cassette, telling what each program is, where in memory it is stored, and where (what number on the recorder's digital counter) to find it on the tape.

## Uploading From Cassette (34)

This utility allows you to input programs from the cassette recorder to the Robot again. Here is how to do it. (Refer again to Figure 12 for this.)

1. Connect a cable (supplied) from the cassette recorder's earphone jack to the Robot's input on the back panel.
  2. Press **3** (utilities) and **4** (upload from cassette) on the Robot's keyboard.
- NOTE:** Each program is replaced in memory exactly where it originally was entered. If you have a program that was originally at 0100, it will go there again from tape, even if there is already a program at 0100. Consider what memory address you need to have on programs, if you intend to have two or more programs in memory at one time.
3. Start the cassette player at the appropriate spot in the cassette tape. If you are not sure where to start, you can identify the high "whistle" of the leader section just before the actual data transfer begins; start the tape at the beginning of this whistle.
  4. The program will be played into memory, in the same place it was originally. Then the Robot will return to the Executive Mode, and say "ready," if you have the voice option.

**NOTE:** Most cassette players will work best if the volume control is set at maximum and the tone control is set at maximum treble. You may need to experiment if you do not get good performance under these conditions.

**Time Set (35)**

The Robot has a clock which you can use if you choose. You can choose a 12 or 24-hour clock and set it exactly, since the clock begins timekeeping when the last button is pressed. The time is shown on the display, when called for by the time display utility. To set the clock:

1. Press **3** (utilities) and **5** (clock set) on the keyboard.
2. The display will show "HH", two blanks, and "SS".
3. Enter the hour by pressing two numbers. You can use either 12 or 24-hour notation. That is, you can enter one o'clock in the afternoon as "13" or "01".
4. In the same manner, push two keys to enter the minutes. Note that the clock hasn't started yet, so you will want to enter the next minute.
5. Enter "00" for the seconds. When you press the last 0, the display will change to show "A", blank, "P", blank, "24".
6. Press the key under the "A" (key D) to indicate AM, press the key under the "P" (key E) to indicate PM, or press the key under the "24" (key F) to indicate a 24-hour clock. When you press one of these keys, the clock will begin and the computer will automatically go to the Executive Mode.

NOTE: The clock will continue to run even if the Robot's power switch is turned off.

**Date Set (36)**

The date display is similar to the time display, and is set as follows:

1. Press the **3** (utilities) and **6** (date set) on the keyboard.
2. The display will show "YY", two blanks, and "dd".
3. Enter two digits for the year, two digits for the month, and two digits for the day (June 12, 1982 would be entered as "820612").
4. When you press the last key, the date will go into memory and the computer will return to the Executive Mode.

**Time Display (37)**

Press keys **3** and **7** to show the clock output on the display. This will remain on the display until you press RESET for the Executive Mode.

**Date Display (38)**

Press keys **3** and **8** to show the date output on the display. This will remain on the display until you press RESET for the Executive Mode.

# Heathkit®

---

## EXECUTIVE MODE (RESET)

Just as initializing provides a needed "home position" for the mechanical parts of the Robot, the Executive Mode provides a home position for the logic process. The Executive Mode is the point from which you enter (execute) the other modes, and the point to which you return when leaving other modes.

Often, the Robot enters the Executive Mode by itself. It does this when you turn it on or when it finishes performing a utility operation. Other times, you may wish to change modes yourself. You begin this by first returning to the Executive Mode.

To enter the Executive Mode, press the RESET key (Figure 13, Illustration Booklet Page 2, shows the keys again). The voice will reply "ready" (if you have the voice option), and the display will show the Hero graphic for about 10 seconds, and then will change to the moving dash (to reduce battery drain). You can enter any other modes from the Executive Mode by pressing the correct key:

- Key **1** selects the Program Mode.
- Key **3** selects the Utility Mode.
- Key **4** selects the Manual Mode.
- Key **7** selects the Learn Mode.
- Key **A** selects the Repeat Mode.
- Key **RESET** returns to the Executive Mode.

Keys 9, C and F (User 1, User 2, and User 3) are user-defined special purpose keys that allow single-key access to memory locations 0030, 0033, and 0036 respectively.

Key D will load an Accessory ROM program, if installed. In that case, the other keys respond differently than just described. See your Accessory ROM Manual.

Pressing any other keys while in the Executive Mode has the same effect as pressing the RESET key.

## MANUAL MODE (4)

The Robot has a teaching pendant (manual remote-control handle). Examine the pendant label, and you will see that the color-coding and symbols make it easy to pick the right switch position and drive the motor in the right direction.

When you select the Manual Mode, the Robot accepts commands from this teaching pendant. You can drive the Robot about and control the arm (optional) and head motion. Note that you can do only one motion at a time with the teaching pendant. You can not, for instance, drive the Robot and simultaneously turn the head. You can, however, drive the Robot and steer its course.

Enter the Manual Mode by pressing the **4** key. Connect the teaching pendant to the lower connector on the Robot's back panel. Notice the various controls shown in Figure 14 (Illustration Booklet, Page 3). These controls work as described in the following sections.

### Trigger Switch

Nothing operates unless you pull the Trigger. The other controls select which motor runs, or which direction the motor runs, but the Trigger actually turns things on.

### Function Switch

Use this switch to select whether you control the arm (and head) or the body (driving the Robot). If you select the ARM position, the Rotary switch will pick the arm and head operations (shown on the pendant label). If you select the BODY position, the Rotary switch will pick the Robot drive operations (three speeds forward, three speeds in reverse, and neutral).

### Rotary Switch

Use this switch to select the arm or head motor you wish to operate, or the forward or reverse speed you wish to drive the Robot. Always be careful to observe the Function switch when you are selecting with the Rotary switch, since you may think you are selecting the GRIPPER control but find that you actually have (FORWARD - FAST) instead.

## Motion Switch

You need to select which direction the arm and head motors run, and you need to turn (steer) the front wheel. This switch controls these functions. The colors on the label help coordinate the actions of the motion and rotary switches. Note that you can use the Motion switch for steering even if the Robot is not moving; with the Rotary switch in the "N" position, the Motion switch will still steer the front wheel, as long as you pull the Trigger switch. This can be quite helpful when the Robot is in a tight place, since you can turn the front wheel first, then drive, to make the Robot spin within its own diameter. Also, remember while driving that you do not have to steer back to the "straight ahead" position; simply release the Motion switch and the front wheel will begin to return to straight ahead, as long as the Trigger is pulled.

### Example: Manual Operation

You will now use the teaching pendant to drive the Robot. Select a space at least 8 feet long and 3 feet wide for the Robot to move in. Also avoid hazzards such as stairs and sharp corners. Finally, choose a smooth surface for the Robot to roll on; linoleum or tile floors are best, then short pile carpet; do not use shag rugs, since it is hard for the Robot to roll on them, and threads can get caught in its undercarriage.

1. Turn the Robot on and then plug in the teaching pendant.
2. Be sure the Robot has been initialized; then press key **4** on the keyboard to enter the Manual Mode.

3. Set the Rotary switch to the "N" position, and the Function switch to the BODY position.
4. Do not pull the Trigger while you set the Rotary switch to the PIVOT – WRIST position (which is also the FORWARD – SLOW position).
5. Pull the Trigger, and the Robot will roll slowly forward. Use the Motion switch to steer LEFT or RIGHT; hold the switch down and the Robot will turn more sharply, release it and the Robot will begin to straighten out. Release the Trigger to stop. Turning the Rotary switch further clockwise will select two faster forward speeds. Turning the Rotary switch counterclockwise will select neutral (only steering works), and three progressively faster speeds in reverse.
6. With the Trigger released, change the Function switch to the ARM position. Set the Rotary switch to the HEAD positon. Press the Trigger and use the Motion switch to turn the head LEFT or RIGHT.
7. If you have the arm option, turn the Rotary switch to each of the other positions and observe what happens as you use the Trigger and the Motion switches. In some instances, the motor may already be at one end of its travel. If this is the case, pushing the Motion switch for that direction of travel will not get you any response; push the other side of the switch and the Robot will respond within a second or two.

To exit the Manual Mode, press the RESET key.

# Heathkit®

---

## LEARN MODE (7)

The Learn Mode is similar to the Manual Mode, with one big exception. In the Learn Mode, the Robot remembers everything you do with it. It can repeat the actions later, in the Repeat Mode. In addition, you can erase mistakes or change the length of movements that went too far. And the actions are somewhat faster when played back in the Repeat Mode. By using the Learn Mode, you can teach the Robot to do just what you want it to (without any wasted moves), more quickly and impressively than you could do it with just the Manual Mode. Note that the arm and head actions repeat more exactly than the drive and steering actions, because even minute errors in steering tend to compound as distance is traveled.

Here is how to use the Learn Mode:

1. Begin with the Robot on, initialized, in the Executive Mode, and with the teaching pendant plugged in.
2. Press the 7 key to enter the Learn Mode.
3. The display will show a 7 with four dashes. Enter the memory address\* where you want the Robot to begin storing the program of movements.
4. The display will again show a 7 with four dashes. This time, enter the maximum memory address\* you will allow for the program. This will stop the program from running into any other program you already have in memory. If you use all of the memory you have allotted for yourself, the display will show "FULL!" and the Robot will refuse further commands. You must exit the Learn Mode by pressing RESET. A typical short program of movement could be stored in the space from 0100 to 0200.

After you enter the second memory address, the display will show 7.F.xxxx, where xxxx equals the initial memory address plus eight.

This is the first command of the program, automatically put in, and tells the Robot to return to its original position when the program is played back.

5. Now you are ready to begin operating the Robot. Use the teaching pendant to perform all of the actions you wish to program into memory. When you are finished, press the RESET key. This will return you to the Executive Mode.

**NOTE:** In the Learn Mode, an automatic pause can be inserted between a rolling forward command and rolling backward. This pause is used to improve travel accuracy by always allowing the Robot to coast to a stop normally before applying a force in the other direction. The pause is inserted in your program when you move the Rotary switch through "N" (going between Forward and Backward) with the Trigger released.

6. To "play back" the program you just put into memory, press A (the REPEAT key), then press D (DO) and the address in memory. If your program has the Robot rolling about, make sure to start from the same position as when you entered the program, or your Robot may end up walking into walls.

### Saving Memory in the Learn Mode

Each time you pull the Trigger on your teaching pendant, an instruction (telling which motor was selected and how far it ran) is stored in memory. Save memory by running each movement all of the way without releasing the Trigger. If you go too far, you can use the back-up feature (which follows) to correct the movement. If you fail to go far enough, pulling the Trigger a second time costs you twice as much memory for that one operation (because the Robot stores the information every time you release the Trigger).

Similarly, moving a Robot mechanism the wrong way takes up a space in memory. If you begin to move a mechanism the wrong way, stop and use the back-up feature to eliminate that movement.

\*The memory address is a hexadecimal number identifying where the byte of information is stored in memory. You can use all of the memory between the number 0039 and 0EDE (3,745 bytes). See the keyboard programming section, Page 25, for further information.

## The Back-Up Feature

The Robot has the ability to "back-up," both in its arm and head motions and its memory. If you enter a wrong motion, you can back up and redo that step to make it right in the program. This feature is also available if you have performed a difficult or complex movement and wish to extract your Robot by "backing out" without changing the program.

Begin "backing up" arm and head motions by pressing the **B** (BACK) key on the keyboard. When you press the Trigger, the Robot will begin to go back through the program you have created. You can back part way through a step, or all of the way. At the end (beginning) of each step, the Robot will pause and a "b" will flash on the display, to let you release the Trigger before going to the next step. If you continue to hold the Trigger, the Robot will back through the next step, and the next, all of the way back to the beginning if you wish. As you back through, you will see the memory address display and motor position display count backwards.

You may stop backing up at any time you wish, midway through a step or between steps. Nothing is actually changed in memory until you press **F** (FWD) and enter a new step. This permanently changes the program along the new branch that you have just created.

If you just used the back-up function to retrace your movements, and don't wish to change anything, you can prevent losing the original program. Just use **RESET** to exit the program, without pressing **F** (FWD). If you back part way through a program, and decide that you want to terminate the program where you now are, you must press **F** (FWD) and enter some new action to establish the end at that point.

## The Reverse The Instruction (RTI) Feature

If you are doing an operation that requires the Robot to do something, then "back-up" and undo the same thing, this feature can put the back-up instructions right into your program. (Like the back-up feature, this applies to the arm and head only.)

When you finish doing the forward steps and wish to Reverse The Instructions, press **RTI** (key #7). An "r" for reverse will show in the display. When you pull the trigger on the control pendant, the arm or head

will begin to back through the last instruction. The operation proceeds just like the back-up feature, one step at a time with a flashing "r" and a pause between steps. However, each of these steps is put into memory. When you wish to stop backing through memory, press "**F**" for forward and enter any other steps. Or simply press **RESET**.

The program will do the steps you entered, then "back-up" through those you chose using **RTI**, and continue on to the end.

## REPEAT MODE (A)

You will normally use the Repeat Mode whenever you want the Robot to do (repeat) a program.\* The program may be a speech, a set of actions from the Learn Mode, or any other program you entered. Occasionally, you may also use the Program Mode, discussed in the following section. Refer to the following section for more information.

Enter the Repeat Mode from the Executive Mode by pressing the **A** (AUTO) key. Then press the **D** (DO) key. The display will show four dashes and "do." You must enter the memory address you used as the start point of the Learn Mode program. When you press the last key, the Robot mechanisms will return to the position they had when the learn program started. Then the Robot will repeat all of the actions that are in the program. You will see that these actions occur somewhat more quickly than when you programmed them in. This is because the Robot does not stop to consider each move, but goes immediately from one to the next.

You may stop the Robot during the Repeat Mode actions, in either of two ways. First, you may press the **RESET** key. This will take the Robot out of the Repeat Mode and into the Executive Mode. The program will not be changed, and you may begin the Repeat action again at the beginning.

In the second way, you can push the **ABORT** key on the experimental board, at any time during the repeat. The display will show the "abort" graphic, then will change to the memory address in the program counter when the program stopped. This can be useful for troubleshooting a program.

\*NOTE: The Repeat Mode is also the beginning point for you, if you wish to examine or modify a program after it has been entered and stored. Information for these operations is integrated into the following section "Programming from the Keyboard."

## PROGRAMMING FROM THE KEYBOARD

The keyboard is the normal means of communicating with a computer. While the Robot's computer does have some other inputs, like the teaching pendant and the various senses, the keyboard input is still the most important. This type of programming is the primary tool to get the Robot to do more than simply rolling around and picking up things. With the right programming, it can do many other complex operations. This section gives the basics of entering programs, understanding where they are stored, and modifying them as needed.

### **THE PROGRAM MODE AND THE REPEAT MODE**

There are actually two modes of program entry. In each mode, you can enter programs, examine and change them, and execute them.

The Program Mode is one of the two modes. Enter the Program Mode from the Executive Mode by pressing the **1** key. In this mode, the keyboard talks more-or-less directly to the microprocessor (computer). This is a very fast way for the microprocessor to handle your program, but the program must be totally in the language that your microprocessor (a 6800 type) recognizes (called "Machine Language"). This means that some of the instructions for the Robot can be unnecessarily long and difficult to write.

The second programming mode is the **A** (AUTO) or Repeat Mode. In this mode, you can use all of the commands you could use in the other mode, plus other additional commands. These other commands are interpreted for the computer, using special permanent programs in a special part of memory. This language is called "Robot Language." When you have these commands available, it is much easier for you to program, but they make it harder (slower) for the computer to read and execute your program. A typical "special" command for the (A) Repeat Mode is the "72" command that you use to tell the Robot to speak.

This command does not exist in the Program Mode (1). Instead, you would have to write a group of commands, telling the Robot to do the same thing.

In summary, the Program Mode can be faster by a factor of ten or a hundred (depending on the exact program), but it can also be that much more difficult to use. Since the Robot's mechanical motions are fairly slow and the computer can do so many operations so fast, the slower and easier method (Repeat Mode, which includes Robot Language) is usually chosen as the best to use.

### **MEMORY CONSIDERATIONS**

All programs and data are entered and handled in the Robot as numbers. The numbering system as you see it and deal with it at the keyboard is hexadecimal. As mentioned before, the hexadecimal numbering system counts like this: 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B, 0C, 0D, 0E, 0F, 10. By counting, you will see that the last number (one zero) is equal to what we would normally call "sixteen." This numbering system is used because it fits very comfortably into the Robot's interior numbering system.

Each number of a program that you enter into the Robot must be stored in the memory. Each place in memory is given an address in hexadecimal. Your Robot has memory numbered from 0000 to FFFF. Some are set aside for special internal use, but you can use anything from 0039 to 0EDE (which is 3750 places, using our normal numbering system).

Whenever you enter, review, or revise a program, you will use the memory, and will have to be able to understand the memory counting (addressing) system. You can become more familiar with the numbering if you will watch the display counter when you are entering the program. The left four spaces show the

memory address while you enter the commands (or data) in the right two spaces; then the memory space counts forward to the next space for the next entry. If you ever wish to change a command, you must go to the same memory address to find it. This is covered in the section on changing programs, on this page.

Another important thing that you need to remember about memory is to put each program where it will fit. If you have one program beginning at memory address 0200 and start another long one at 0100, the new one could extend right into the one at 0200. If this happens, the computer will not warn you, but will simply put the new program in place, erasing the beginning of the old one. This is one good reason to place the first program at a low number (such as 0040) and then put each additional one at a higher number; then a new one will not "count" right into the beginning of an older one.

Finally, remember that the memory you use is not permanent. If you turn the Robot off, the power to the memory is off and your program will be lost. This is a good reason for storing any long programs on cassette tape (see Utility Mode, Download to Cassette, Page 19).

## **ENTERING A PROGRAM**

A standard, easy way to enter a program is to use the auto numbering feature. The instructions below use that feature. Since the A (AUTO) Mode offers more ease of programming and will be most useful to all but expert programmers, we will use that Mode for the following.

1. Press **A** to enter the Programming (Repeat) Mode from the Executive Mode.
2. Press **A** a second time. This tells the computer to number the memory addresses automatically.
3. Enter a 4-digit hexadecimal number to tell the computer where to begin storing the program.

4. Enter the program. After each two key presses, the memory counter will automatically increment the address and two blank spaces will show for your next entry.
5. If you make a mistake while entering the program, note the memory address and continue on, finishing the program. After you complete the program entry and return to the Executive Mode, you can come back to correct errors, using the "Checking/Changing A Program" instructions in the following section.
6. If you have data or commands that you wish to change after seeing how the program runs, make a note of their memory addresses so you can make the changes more easily.
7. After you enter the last key press, press **RESET**. This returns you to the Executive Mode. From there, you can decide to run or revise the program, enter another program somewhere else in memory, or do anything else in the Robot's capabilities.

For more information on programming the Robot, refer to the example on Page 27, to the "More Complex Operations" section on Page 44, and to the Technical Manual.

## **CHECKING/CHANGING A PROGRAM**

Once a program is "in memory," you can review it and make any changes you need. The process is simple and can be done in either the (1) Program Mode or the (A) Repeat Mode, just as the programming is.

1. Press the **A** key.
2. Press the **E** (EXAM) key to "examine" the memory.

# Heathkit®

---

3. Enter the memory address where you wish to start examining.
4. Press the **F** (FWD) and **B** (BACK) keys, so you can look forward and backward through the memory addresses, until you have seen all that you wish to see. The left four display spaces will show the memory address, and the right two spaces will show the command or data that is contained in that address.
5. If you see information in a memory address that you wish to change, press the **C** (CHAN) key. The right two spaces in the display will go blank, allowing you to enter the information you wish to place there.
6. You may continue to go forward and backward, and change information until you are satisfied. Then simply exit the examine operation by pressing RESET.

## RUNNING A PROGRAM

The Program and the Repeat Modes can both be used for running programs, but they have their differences, as discussed on Page 25. The Repeat Mode (**A**) is slower, but will process programs in both "Machine Language" and the easier-to-use "Robot Language." The Program Mode (**1**) is faster, but will only process programs that contain exclusively "Machine Language." This is how to run programs, once they have been entered.

1. Press the correct key, (**1** or **A**).
2. Press the **D** (DO) key.

3. Enter the memory address of the beginning of the program you want performed.
4. The Robot will begin as soon as you press the last key.

You may stop the program at any time by pressing either the RESET or the ABORT key. The RESET key will send the Robot to the Executive Mode, while the ABORT key will give you the last memory address in the computer's program counter, if you wish to locate some flaw in the program.

## PROGRAM EXAMPLE

This program example is typical of a program that you might enter. It uses the language that is presented and explained in the Technical Manual. When you begin using the Technical Manual, you will probably do much more complex programs. This program is presented here just to help you practice entering and correcting a program while the information is fresh in your mind. It also helps familiarize you with what a program is like, so you will be ready for the Technical Manual.

The program tells the Robot to go forward a small distance, wait, turn its head around, wait, back up the same distance, wait, turn its head forward again, wait, and return to the Executive Mode. Practice by entering this program and running it. If it does not run properly, examine and correct it as discussed in "Checking/Changing A Program." The RESET and ABORT keys will stop the program if you detect a problem.

Commands are given in "Robot Language," and must be entered in the Repeat Mode for the Robot to understand them. The Program Mode will not work because it recognizes only machine language.

<u>MEMORY ADDRESS</u>	<u>INPUT *</u>	<u>COMMENT **</u>
	A	Repeat Mode.
	A	Automatic numbering.
	0100	Start entering at memory address 0100.
0100	D3	Instruction to drive a motor.
0101	10	The motor is the drive motor, run it forward.
0102	10	Go 10 units.
0103	BD	Jump to the subroutine at the address given.
0104	01	Address is (0119).
0105	19	/
0106	D3	Upon return from subroutine, drive a motor.
0107	D0	The head motor, to the right.
0108	60	Go 60 units.
0109	BD	Jump to subroutine again.
010A	01	Subroutine address 0119.
010B	19	/
010C	D3	Upon return, drive a motor.
010D	14	The drive motor, backwards.
010E	10	Go 10 units.
010F	BD	Jump to subroutine again.
0110	01	At this address (0119).
0111	19	/
0112	D3	Upon return, drive a motor.
0113	D4	The head motor, to the left.
0114	60	Go 60 units.
0115	BD	Jump to subroutine again.
0116	01	At this address (0119).
0117	19	/
0118	3A	Return to Executive Mode when you get here.

SUBROUTINE

0119	CE	Put the following number into the Index Register.
011A	01	The number is 0100.
011B	00	/
011C	09	Subtract 1 from Index Register.
011D	26	Check if Index Register is zero.
011E	FD	If not, go back to "subtract 1" command.
011F	39	When you get here go back to the next step of the main program.

\*These are the numbers you will enter.

\*\*This column contains approximate explanations of what your entries tell the computer.

# Heathkit®

---

The part of the program stored in 0119 through 011F is called a subroutine, and it provides the "wait" period between the various actions. When the program "jumps" to it, the subroutine tells the computer to take the number 0100 (remember this and all the other numbers are in hexadecimal) and subtract 1, over and over again, until the number is zero. This is a common method of creating a pause in the program.

Note that a pause can be created more easily by entering the command "8F" followed by a 4-digit hexadecimal number. The number indicates how

many time segments the pause should last. Each segment is about 1/16 of a second. Thus "8F0010" would mean a pause of sixteen (remember 10 in hex is sixteen) segments, or about 1 second.

After you get your program to run correctly, experiment by changing any of the variables (the numbers that tell "how far," or the "how long" number in the subroutine). An example would be the "10" stored at memory address 0102. Making this number larger would make the Robot go farther forward before stopping.

## MAKING THE ROBOT TALK

The optional speech synthesizer can produce 64 basic sounds (called phonemes) that are needed for the English language (and many others). One of the wonderful things about a synthesizer is that you can make it simulate a wide range of human speech by putting the different sounds together properly. While the speech may not sound as "human" as a speech recording, you do have the advantage of being able to make it say anything you like, and you will quickly become accustomed to it and will be able to understand it clearly within a few minutes.

### PROGRAMMING THE WORDS

The phoneme chart shows the sounds that are available for you to use. The "phoneme code" is the hexadecimal number that you enter in your speech program, to call that particular phoneme. The "phoneme symbol" indicates the sound that the

code represents, and the underlined portion of the "example word" shows where you can find that sound in normal speech.

Before you enter the phonemes, you need to begin the program and tell the CPU that it will be a speech program. The preceding five pages of this Manual deal with beginning, entering, correcting, and running programs. You should read them and practice the program example before you program speech. The command 72, in Robot Language (Repeat Mode), tells the CPU to read the phonemes and make the Robot speak.

A sample program that will make the Robot speak follows. Press the key or keys for each step in order. When you have finished entering the program, press the RESET key and the Robot will return to the Executive Mode, ready for you to run or correct the program. Use the preceding five pages for help in checking and running your speech program.

<u>MEMORY ADDRESS</u>	<u>INPUT</u>	<u>COMMENT</u>
	RESET A A 0090	Executive Mode. Enter Repeat Mode (Robot Language). Use automatic memory address incrementing. Selects the address in memory where you want to start.
0090 0091 0092 0093 0094	72 00 95 20 FE	Speak the phonemes... that start at... 0095 in memory. This command and the next one tell... the CPU to wait here when done speaking.
0095 0096 0097 0098 0099 009A	1B 3B 18 35 37 3F	This is the first phoneme (H). Phoneme (E). Phoneme (L). Phoneme (O). Phoneme (U). The "stop" phoneme (needed at the end).
009B 009C	FF RESET	This indicates the end of the phonemes. Sends Robot back to Executive Mode.

# Heathkit®

## PROGRAM NOTES:

1. The program does not need to start at 0090. You can start at any memory address of 003F or higher. However the end of the program cannot extend beyond the address 0EE0.
2. You can store a number of speeches at different addresses, and call up the one you want by sending the computer to the proper address (see "Playing Back a Speech Program," which follows).
3. You need a 03, 3F, or 3E (silent pause) at the end of every speech, or the voice will trail off with a funny sound.
4. If you turn the Robot off, it will forget the speech program and you will have to reenter it.

The easiest and quickest way to program your Robot to speak, is to refer to the dictionary supplied as part of your literature. This dictionary gives a large number of words, and their phoneme codes. You can look up the words, write down the codes, and enter the program. Remember to include the initial entries (listed above) that tell the computer that you are entering a speech. End with a pause and the "FF" that marks the end.

A second method of creating speech is to work out the sounds yourself, using the phoneme chart. This takes longer, but is very satisfying and will increase your understanding and appreciation of human speech. In addition, you will be able to create a wider range of sounds and will not depend on the dictionary.

## PHONEME CHART

Phoneme Code	Phoneme Symbol	Duration (ms)	Example Word
00	EH3	59	jacket
01	EH2	71	enlist
02	EH1	121	heavy
03	PA0	47	no sound
04	DT	47	butter
05	A2	71	made
06	A1	103	made
07	ZH	90	azure
08	AH2	71	honest
09	I3	55	inhibit
0A	I2	80	inhibit
0B	I1	121	inhibit
0C	M	103	mat
0D	N	80	sun
0E	B	71	bag
0F	V	71	van
10	CH*	71	chip
11	SH	121	shop
12	Z	71	zoo
13	AW1	146	lawful
14	NG	121	thing
15	AH1	146	father
16	OO1	103	looking
17	OO	185	book
18	L	103	land
19	K	80	trick
1A	J*	47	judge
1B	H	71	hello
1C	G	71	get
1D	F	103	fast
1E	D	55	paid
1F	S	90	pass

Phoneme Code	Phoneme Symbol	Duration (ms)	Example Word
20	A	185	day
21	AY	65	day
22	Y1	80	yard
23	UH3	47	mission
24	AH	250	mop
25	P	103	past
26	O	185	cold
27	I	185	pin
28	U	185	move
29	Y	103	any
2A	T	71	tap
2B	R	90	red
2C	E	185	meet
2D	W	80	win
2E	AE	185	dad
2F	AE1	103	after
30	AW2	90	salty
31	UH2	71	about
32	UH1	103	uncle
33	UH	185	cup
34	O2	80	for
35	O1	121	aboard
36	IU	59	you
37	U1	90	you
38	THV	80	the
39	TH	71	thin
3A	ER	146	bird
3B	EH	185	get
3C	E1	121	be
3D	AW	250	call
3E	PA1	185	no sound
3F	STOP	47	no sound

\*T must precede CH to produce CH sound.

D must precede J to produce J sound.

**PHONEME NOTES:**

1. Different phonemes may produce the same sound, but have different durations (length of sounding). Listen to "EH3," "EH2," and "EH1," then listen to "I3," "I2," and "I1." The difference in their length may be what you need to fix a word that sounds "clipped" or "lopsided."
2. Remember that you are free to use two or three of the same (or similar) phonemes in a row, to smooth out a word's sound. Usually, you will use vowel sounds (A, E, I, O, U) for this.
3. Cultivate a good ear for speech patterns and word sounds. For instance, the word "I" is a diphthong (that is, it contains two sounds, "AH" and "E"). With work, you will recognize special sounds, accents, and changes of pitch (which you will be able to reproduce using the inflection capability).
4. Refer to the Examples after "Inflection" to see how phonemes can be used to create words, generate dialects, and add emphasis and musical effects.
5. When you first program "by ear," insert extra silent pauses between the words. This will give you space to insert phonemes, if needed, when you adjust your program for better sound; by providing the extra spaces you can add a phoneme without having to reenter the rest of the program. In addition, it will be easier to hear each separate word, so you can analyze and adjust. However, normal speech patterns will run together without any spaces between the words; you may choose to do this when you have your complete phrase figured out.
6. Become very familiar with the process for changing entries in a program ("Checking/Changing A Program," Page 26), since you are sure to want to modify the sounds after you hear them a few times.
7. Be sure to write down the phoneme codes for phrases that seem to work especially well for you. Choose a good place for saving these homemade phrases, such as in the back of this User's Manual or in the dictionary.
8. Refer to "Download To Cassette," Page 19, to preserve the long speeches after you have perfected them. But don't neglect to write the phoneme codes down too, as a back-up, and reference when looking for a specific word.

**PLAYING BACK A SPEECH PROGRAM**

Once you have a program entered, you will want to hear it. You can run a speech program just as you would any other (see "Programming From the Keyboard" for added information). These keystrokes will run your program.

<u>KEY(S)</u>	<u>EXPLANATION</u>
RESET	Into the Executive Mode.
A	Repeat Mode.
D	Do the program at the address below.
#####	The address where you started the program.

The program will begin to run as soon as the last key is pressed.

# Heathkit

---

## PROGRAMMING INFLECTION

Many people think of synthesized speech as dull and droning. Often that is the case. But Hero has the ability to speak with inflection. The voice has four pitch levels, and you can program phonemes to be spoken at any one of the levels. Thus the Robot can say, "I saw him there," answering the question "who?", or "I saw him **there**," answering the question "where?" In addition, some inflection can be used within a word to make the accented syllable stand out. By using the inflections, you can make Hero's speech more interesting and more understandable. Finally, since the inflection is due to differences in pitch, you can make

the Robot sing a tune (as long as it only has four different notes). The intervals are roughly the same as the notes D, E, G, and B, going up the scale.

This is how you create the inflection. The phoneme chart shows the phoneme code for one set of sounds, those spoken at the lowest pitch. You can program sounds at the next higher pitch by adding the number "hexadecimal 40" to any phoneme code. Similarly, you could raise the pitch again by adding another hex 40, and raise it even again by adding yet a third hex 40. Use the following example chart and your keyboard to see the change clearly.

NOTE: The "Stop" phoneme code (3F) is the only code which should **never** be raised in inflection. Raising a 3F to a "BF" or "FF" changes the command.

### EXAMPLE:

BASIC PHONEME CODE	RAISED ONE LEVEL	RAISED TWO LEVELS	RAISED THREE LEVELS	SOUND PRODUCED*
00	40	80	C0	"EH3"
18	58	98	D8	"L"
2E	6E	AE	EE	"AE"
3D	7D	BD	FD	"AW"

\* See phoneme chart.

Refer to "Speech and Inflection Examples," Page 34 for actual speeches you can enter, and "Special Phrases In Permanent Memory," Page 38 for speeches that are already programmed into the Robot.

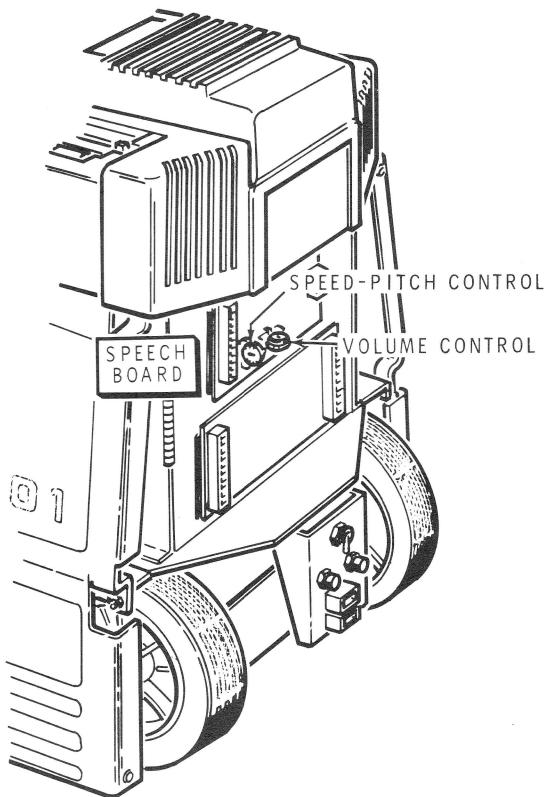


FIGURE 15

## ADJUSTMENTS

There are two adjustments for the Robot's speech. One is for volume and the other is for the combination of speed and pitch. The Volume control is self-explanatory, but the second control needs a note of explanation. If you make the voice sound higher, you will also make the words come faster. With this control, you can make the voice of a fast-talking little imp or a slow-talking giant. Robot speech is easiest for others to understand, however, if it is kept rather slow and low pitched.

The controls are shown in Figure 15, and are found on the speech board on the back of the Robot chassis. If you ever wish to change these controls, you can reach them by removing the rear body panel. It is easiest to make these adjustments while repeatedly pressing the RESET button; the Robot will keep saying the word "ready" for you to listen to while you adjust.

## SPEECH AND INFLECTION EXAMPLES

The following examples should be fun for trying out the Robot's speech capabilities. In addition, they can be very helpful as a reference, since some word sounds are more complex than you may think. Use the examples to study the use of inflection and the surprising sounds that are present in some words.

The darker printing shows which word should sound emphasized. The numbers 0, 1, 2, and 3, in the "INFL." column show which level of inflection each word or syllable has. To enter these programs, you must first enter the few commands for "speech," from Page 30. Enter the phonemes by going down one column, then down the next. The notes after an entry are there to point out some of the worthwhile points about obtaining good speech.

**Heathkit®**

"I only take instructions from Jim\*. He tickles my keyboard. Ha, ha, ha!"

\*Enter your own name.

<u>CODE</u>	<u>SOUND</u>	<u>INFL.</u>	<u>CODE</u>	<u>SOUND</u>	<u>INFL.</u>	<u>CODE</u>	<u>SOUND</u>	<u>INFL.</u>
**								
15	AH1	0	1D	F	0	15	AH1	0
00	EH3	0	2B	R	0	00	EH3	0
09	I3	0	32	UH1	0	09	I3	0
29	Y	0	23	UH3	0	29	Y	0
75	O1	1	0C	M	0	59	K	1
74	O2	1	9E	D	2	61	AY	1
4D	N	1	9A	J	2	69	Y	1
58	L	1	4B	I1	1	0E	B	0
69	Y	1	49	I3	1	35	O1	0
2A	T	0	4C	M	1	34	O2	0
06	A1	0	3E	PA1	0	2B	R	0
21	AY	0	3E	PA1	0	1E	D	0
29	Y	0	3E	PA1	0	3E	PA1	0
19	K	0	3E	PA1	0			
0B	I1	0	5B	H	1	DB	H	3
09	I3	0	7C	E1	1	D5	AH1	3
0D	N	0	69	Y	1	C8	AH2	3
5F	S	1						
6A	T	1	2A	T	0	9B	H	2
6B	R	1	0B	I1	0	95	AH1	2
72	UH1	1	09	I3	0	88	AH2	2
71	UH2	1	19	K	0			
59	K	1	23	UH3	0	1B	H	0
11	SH	0	18	L	0	15	AH1	0
23	UH3	0	12	Z	0	08	AH2	0
0D	N	0	0C	M	0	3E	PA1	0
12	Z	0						

## NOTES:

\*\*First, enter the Mode and memory address information, and the speak command, as shown on Page 30.

1. The first word, "I" is actually a combination of vowel sounds. You will find that nearly all vowel sounds are complex like "I" and require more than one phoneme.
2. The word "Jim" begins with the D phoneme, not the J.
3. The stressed syllable in "in-STRU C-tions" and "KEY-board" are achieved by using a higher inflection.
4. The "laugh" at the end uses inflection in another application.

"Stand back! Or I'll blast you with my laser gun."  
(Laser sound)

CODE    SOUND    INFL.

*		
5F	S	1
6A	T	1
6F	AE1	1
40	EH3	1
4D	N	1
5E	D	1
CE	B	3
EF	AE1	3
C0	EH3	3
D9	K	3
3E	PA1	1
3E	PA1	1
34	O2	0
34	O2	0
2B	R	0
15	AH1	0
00	EH3	0
09	I3	0
29	Y	0
18	L	0
4E	B	1
58	L	1
6F	AE1	1
40	EH3	1
5F	S	1
6A	T	1
22	Y1	0
36	IU	0
37	U1	0
37	U1	0

CODE    SOUND    INFL.

2D	W	0
0B	I1	0
09	I3	0
39	TH	0
0C	M	0
15	AH1	0
00	EH3	0
09	I3	0
29	Y	0
98	L	2
86	A1	2
A1	AY	2
A9	Y	2
92	Z	2
42	EH1	1
7A	ER	1
5C	G	1
73	UH	1
4D	N	1
3E	PA1	0
1E	D	0
1A	J	0
1E	D	0
1A	J	0

(Repeat the 1E & 1A about eight more times to make the laser sound.)

3E      PA1      0

NOTES:

\*First, enter the Mode and memory address information, and the speak command, as shown on Page 30.

1. The rising inflection at "stand back!" makes the exclamation point.
2. There are many sounds you can make for space ships and laser guns, by repeating a few sounds over and over, or changing the inflection on just one sound as you repeat it.

**Heathkit®**

**"Everyone stares at me. Maybe it's because I'm so short."**

<u>CODE</u>	<u>SOUND</u>	<u>INFL.</u>	<u>CODE</u>	<u>SOUND</u>	<u>INFL.</u>
*					
42	EH1	1	0E	B	0
4F	V	1	29	Y	0
7A	ER	1	0B	I1	0
69	Y	1	09	I3	0
6D	W	1	2A	T	0
72	UH1	1	1F	S	0
63	UH3	1	0E	B	0
4D	N	1	29	Y	0
5F	S	1	19	K	0
6A	T	1	3D	AW	0
80	EH3	2	12	Z	0
80	EH3	2	15	AH1	0
BA	ER	2	00	EH3	0
52	Z	1	09	I3	0
6F	AE1	1	29	Y	0
40	EH3	1	0C	M	0
6A	T	1	1F	S	0
0C	M	0	35	O1	0
3C	E1	0	37	U1	0
29	Y	0	51	SH	1
3E	PA1	0	74	O2	1
3E	PA1	0	74	O2	1
3E	PA1	0	6B	R	1
0C	M	0	6A	T	1
06	A1	0	3E	PA1	0
21	AY	0			
29	Y	0			

\*First, enter the Mode and memory address information, and the speak command, as shown on Page 30.

**NOTES:**

1. Special inflection raises the center of "stares" instead of the whole word. Note that the end of "stares" is a Z sound, not an S.
2. Inflection gives a slight emphasis to "short."

"Shave and a haircut, two bits." (Music)

<u>CODE</u>	<u>SOUND</u>	<u>INFL.</u>
*		
91	SH	2
86	A1	2
BC	E1	2
8F	V	2
83	PA0	2
6F	AE1	1
4D	N	1
5E	D	1
73	UH	1
43	PA0	1
5B	H	1
42	EH1	1
7A	ER	1
59	K	1
73	UH	1
6A	T	1
3E	PA1	0
03	PA0	0
EA	T	3
F6	IU	3
E8	U	3
C3	PA0	3
8E	B	2
A7	I	2
AA	T	2
9F	S	2
BE	PA1	2

#### NOTES:

1. For higher level inflections (INFL. = 2 or 3), the "no sound" phonemes may have to be at the same level as the preceding word. Otherwise, the end of that word may sound funny.
2. You may wish to adjust the timing, or flow, of words by using the "no sound" phonemes. This can make words more natural sounding, can separate words that seem to run together (for example, "my eye"), add emphasis, or help the timing for music or short poems.

#### SPECIAL PHRASES IN PERMANENT MEMORY

Some of the computer's memory contains instructions that are permanently built into it. The Robot Language, utilities, and phonemes are three examples of permanent instructions. There was also some space in this permanent memory to store some complete speeches, such as the word "ready," that you hear when you press the RESET key. You can use these speeches by entering the "speak" command (72) followed by the memory address of the speech. The computer will speak the phrase, and return when it is done. To string a group of phrases together, use the speak command, the memory address of the phrase, another speak command, the memory address of the next phrase, and continue until the last phrase.

The phrases that are available in permanent memory are listed in the separate dictionary.

\*First, enter the Mode and memory address information, and the speak command, as shown on Page 30.

## USING THE ROBOT SENSES

Your Robot has five senses. It can sense time, light, sound, motion around it, and the distance to an object in front of its ultrasonic range detector. Refer to Figure 16, Illustration Booklet Page 3, to locate the various transmitters, receivers, and sensors for the different Robot senses.

With more sophisticated programming, each of these senses can be used in concert with the other senses and the Robot's mobility to perform some sophisticated tasks. The discussions and small programs that follow will give you an indication of what the Robot can do if you choose to become a skillful Robot programmer.

### TIME

The Robot has built-in clock and calendar circuits that you can run if you wish. They will continue to operate as long as the Robot has sufficient power from

its batteries or charger. Turning the Robot off does not stop the clock or calendar. The time and date information is available to the computer through special permanent utility programs, and you can use it creatively in other programs by calling the information from those circuits. For instance, you could write a program to have the Robot announce the time every fifteen minutes, but only if there was at least a certain amount of light within the room (showing that it was daytime, or someone was in the room with the lights on). Or, you could use the clock to have the Robot turn on its motion detector at a specified time every night and stand guard until a specified time in the morning. Further, you could have the Robot announce whenever the motion detector senses anything.

Setting and reading the time and calendar are discussed in the Utility Mode information, Page 20. More help for complex programming involving the clock or calendar is available in the Technical Manual.

NOTE: If you write programs that use both light and sound sensors (described on Pages 40 and 41), do not use disable commands when you switch from one sensor to the other unless you insert a delay (pause command) of at least two seconds.

**LIGHT**

The Robot has a light-sensitive resistor and can sense 256 different levels of light. You can activate the light sensor and have the Robot perform other actions based on the amount of light it senses. One fun example could be to have the Robot pull a light switch chain to turn the light on, when it got dark.

The program that follows will turn on the light sensor, store the light reading, display the reading, wait part of a second, and then return to the beginning of the program again. Note that the program uses two subroutines that are part of the computer's permanent memory ("clear the display" and "show on the display").

In addition, when the program is run, the first 8 commands check to see if the Robot is using the Robot Language (Repeat Mode). This is the language necessary for this program, since there are some commands that only Robot language will recognize. If the Robot is in the Program Mode (Machine Language), the command "3F" changes it to the Repeat Mode (Robot Language), so that this program will run.

The memory addresses for this program and the three that follow it were arbitrarily selected to be from 05FF to 066B. The "Comments" section assumes that you will use the given memory address to enter these programs.

<u>MEMORY ADDRESS</u>	<u>INPUT *</u>	<u>COMMENT **</u>
0615	B6	Read the number...
0616	0E	which is found at 0EE1.
0617	E1	(0 = Repeat Mode).
0618	81	Compare that number...
0619	00	to zero.
061A	26	If not equal...
061B	01	go ahead to 061D.
061C	3F	Otherwise, change from Program Mode to Repeat Mode.
061D	41	Turn on the light sensor.

<u>MEMORY ADDRESS</u>	<u>INPUT *</u>	<u>COMMENT **</u>
061E	83	Go to the Machine Language Mode, which is faster than Robot Language.
061F	BD	Go to the "clear the display" subroutine... at the address F64E.
0620	F6	/
0621	4E	Read the information (light sensor)...
0622	B6	which is found at C240.
0623	C2	/
0624	40	Go to the "show on display" subroutine...
0625	BD	which is stored at F7AD.
0626	F7	/
0627	AD	Load the following number into register.
0628	CE	The number is 1000 (hexadecimal).
0629	10	/
062A	00	Subtract 1 from the register.
062B	09	If the register is not zero, go...
062C	26	back to 062B.***
062D	FD	Everytime you reach here, go....
062E	20	back to memory location 061F.***
062F	EF	

\*You put in the commands to the Robot by pressing these keys, after entering the Repeat Mode and automatic numbering, and entering the address for the first memory location.

\*\*The comments explain a little bit about what the commands tell the computer to do. More explanation is available in the Technical Manual.

\*\*\*Find the new address by starting at the current address (call it FF) and counting in hexadecimal either forward (00, 01, 02,...), or backward (FE, FD, FC,...) until you get to the number given in the program. In this program, you count backward to FD, and then to EF.

# Heathkit®

---

## SOUND

Like the light detector detects light , the sound sensor can sense noise at 256 different levels. Through skillful programming, you can have the Robot make the desired response to the presence of noise. One clever application would be to have the Robot say "Turn the TV set down!" when the noise level in the TV room got too high. You could also use the clock for more complex commands. The Robot could respond to quick noises (such as hand-claps) within one second, by saying, "Yes Master, what is your command?" or performing some other task.

The following program is like the previous program for light, except that this time, it uses the command for the sound sensor.

<u>MEMORY ADDRESS</u>	<u>INPUT *</u>	<u>COMMENT **</u>
0630	B6	Read the number...
0631	0E	which is found at 0EE1.
0632	E1	(0 = Repeat Mode).
0633	81	Compare that number...
0634	00	to zero.
0635	26	If not equal...
0636	01	go ahead to 0638.
0637	3F	Otherwise, change from Program Mode to Repeat Mode.
0638	42	Turn on the sound sensor.
0639	83	Go to the Machine Language Mode, which is faster than Robot Language.
063A	BD	Go to the "clear the display" subroutine... at the address F64E.
063B	F6	/
063C	4E	/
063D	B6	Read the information (sound sensor)... which is found at C240.
063E	C2	/
063F	40	Go to the "show on display" subroutine...
0640	BD	

<u>MEMORY ADDRESS</u>	<u>INPUT *</u>	<u>COMMENT **</u>
0641	F7	which is stored at F7AD.
0642	AD	/
0643	CE	Load the following number into register.
0644	30	The number is 3000 (hexadecimal).
0645	00	/
0646	09	Subtract 1 from the register.
0647	26	If the register is not zero, go...
0648	FD	back to 0646.***
0649	20	Everytime you reach here, go....
064A	EF	back to memory location 063A.***

\*You put in the commands to the Robot by pressing these keys, after entering the Repeat Mode and automatic numbering, and entering the address for the first memory location.

\*\*The comments explain a little bit about what the commands tell the computer to do. More explanation is available in the Technical Manual.

\*\*\*Find the new address by starting at the current address (call it FF) and counting in hexadecimal either forward (00, 01, 02,...), or backward (FE, FD, FC,...) until you get to the number given in the program. In this program, you count backward to FD one time, and backward all the way to EF the next time.

**MOTION**

The motion detector is an ultrasonic device that can detect motion in the same room with the Robot. One application of the motion detector would be to have a Robot guard at night. You can program the Robot to announce when it detects any movement during the night. Another application would include the clock. The Robot could become a "talking clock," and announce the time at regular intervals — if it detected motion in the room. It would be quiet when everyone was out of the room (sleeping, for instance), and would announce the time only when there was someone around to hear it.

The following program counts the number of times the Robot detects motion. It turns the motion sensor on, waits until the sensor indicates motion, counts that indication, pauses about one half second, then waits for another indication. This program is relatively complex, when compared to the others you have seen, so the comments may not be of much value to you unless you have some computer background.

In addition, when the program is run, the first 8 commands check to see if the Robot is using the Machine Language (Program Mode). This is the best language for this program, since it runs more quickly than the Robot Language. If the Robot is not in the Program Mode (Machine Language), the command "83" changes it to that Mode, so that this program will run most efficiently.

<u>MEMORY ADDRESS</u>	<u>INPUT</u>	<u>COMMENT</u>
0650	B6	Read the number...
0651	0E	which is found at 0EE1
0652	E1	(0 = Repeat Mode).
0653	81	Compare that number...
0654	FF	to FF.
0655	26	If not equal...
0656	01	go ahead to 0658.
0657	83	Otherwise, change from Repeat Mode to Program Mode.
0658	0E	Clear interrupt mask.
0659	7F	Clear (empty) the contents of....
065A	00	memory address 0040.
065B	40	/
065C	86	Load into the computer the command...
065D	7E	7E (a jump command).

<u>MEMORY ADDRESS</u>	<u>INPUT</u>	<u>COMMENT</u>
065E	97	Store the command.... at this address (0027).
065F	27	Load the following number in the computer...
0660	CE	The number is 066A (hexadecimal), the address of the interrupt routine.
0661	06	Store this number at... memory address 0028 and 0029.
0662	6A	Change to Robot Language.
0663	DF	Turn on the motion detector.
0664	28	Change back to Machine Language.
0665	3F	Every time you reach here, go...
0666	4B	to memory address 0668 ("wait here").
0667	83	
0668	20	
0669	FE	

**INTERRUPT ROUTINE**

Every time the motion sensor detects a movement, it generates an "interrupt" which sends the computer to this interrupt routine.

066A	96	Load into the computer the contents of...
066B	40	memory address 0040 (total of times that motion has been detected).
066C	4C	Add 1 to the total.
066D	97	Store the results at....
066E	40	memory address 0040.
066F	BD	Jump to "select where to show digit" subroutine... (which is at address F64E).
0670	F6	/
0671	4E	Jump to "print on display" subroutine...
0672	BD	(which is at address F7AD).
0673	F7	/
0674	AD	End of subroutine.
0675	39	

The interrupt routine is cancelled in firmware, after all of the potential interrupts (in addition to the motion sensor) have been checked by the computer.

# Heathkit®

---

## ULTRASONIC RANGING\*\*

There is a sonar range finder in the Robot's head. The transmitter (shown in Figure 16, Illustration Booklet Page 3) sends out an ultrasonic signal (too high pitched to be heard by human ears). The time it takes for the echo to reach the receiver, tells how far it is to the object that caused the echo.

This program turns on the sonar, takes a reading, displays that reading (in hexadecimal), waits for part of a second, and then repeats the whole operation.

In addition, when the program is run, the first 8 commands check to see if the Robot is using the Robot Language (Repeat Mode). This is the language necessary for this program, since there are some commands that only Robot Language will recognize. If the Robot is in the Program Mode (Machine Language), the command "3F" changes it to the Repeat Mode (Robot Language), so that this program will run.

MEMORY ADDRESS	INPUT	COMMENT
05F8	B6	read the number...
05F9	0E	which is found at 0EE1.
05FA	E1	(0 = Repeat Mode).
05FB	81	Compare that number...
05FC	00	to zero.
05FD	26	If not equal...
05FE	01	go ahead to 0600.
05FF	3F	Otherwise, change from Program Mode to Repeat Mode.
0600	45	Turn on, and begin sampling, sonar. Store reading at special place (0010) in memory.
0601	83	Go to Machine Language Mode, which is much faster than operating in the Robot Language.

MEMORY ADDRESS	INPUT	COMMENT
0602	BD	Jump to "clear display" subroutine...
0603	F6	at the address F64E.
0604	4E	/
0605	96	Load into computer the contents of...
0606	11	special address (0011) (Sonar reading).
0607	BD	Jump to "print on display" subroutine...
0608	F7	(which is at F7AD).
0609	AD	/
060A	CE	Load the following number in register.
060B	10	The number is 1000 (hexadecimal).
060C	00	/
060D	09	Subtract one from the number.
060E	26	If the number is not yet zero go...
060F	FD	back to 060D.*
0610	20	Everytime you reach here, go....
0611	F0	back to memory 0602.*

This completes the section on the Robot's senses.

\*Find the new address by starting at the current address (call it FF) and counting in hexadecimal either forward (00, 01, 02,...), or backward (FE, FD, FC,...) until you get to the number given in the program. In this program, you count backward to FD one time, and backward all the way to F0 the next time.

\*\*NOTE: Ultrasonic systems use acoustic waves, just like sound waves, only higher pitched (32 kHz). Consequently, it is possible for the presence of other high pitched sounds (ultrasonic "noise") to confuse the Motion or Ranging devices. Ultrasonic noise can come from air conditioning and other machinery, from other ultrasonic devices (like TV remote controls or home intrusion alarms), and also from the upper harmonics of "tinkling" noises (such as keys jingling and glass breaking).

## MORE COMPLEX OPERATIONS

This User's Manual has dealt with each of the various capabilities that your Robot has. But these discussions were at a pretty basic level. Your Robot can do much more, as your programming skills increase. "More Complex Operations" is the end of this Manual, but just the beginning of your accomplishments with the Hero Robot. Use the Technical Manual for more about programming, and study booklets about machine language programming. Finally, save your programs to swap ideas with other Hero owners.

This section of the Manual will indicate just a few of the capabilities "up your Robot's sleeve" and provide a collection of some ideas for impressive operations that are possible through the proper programming.

### SLEEP OPERATION

You may, at times, wish to turn off much of the Robot without losing the programs you have in memory. This will allow you to save battery power if you are operating only on the batteries. In addition, you might have a program in which the Robot operates for a short while, then "rests" for some period of time before resuming.

The sleep operation is very useful for both of these needs. A command exists in robot language that turns off power to almost everything except the memory for 10 seconds. The command is 87, and it is followed by a 4-digit hexadecimal number that tells how many times to do the command. If you want your Robot to stand guard at night and check the area with its motion detector every 30 seconds, you can enter the command 87 0003 in the program. The Robot will shut down for three 10-second periods when it comes to that command, then take up right where it left off.

NOTE: The sleep command only works if the Sleep switch on the experimental board is set to the SLEEP

position. If the switch is in the Normal position, the computer reads the sleep command but then goes right on to the next command. WARNING: If the switch is in the SLEEP position when you turn the Robot on or press the RESET key, the Robot will go to sleep. This particular rest could last for up to 7-1/2 days. To return from this accidental sleep, change the switch to the NORMAL position; the Robot will "wake up" at the end of the next 10-second period.

### SIMULTANEOUS OPERATIONS

The many operations have been addressed on a one-at-a-time basis because that is the easiest to do and understand. But the computer is capable of doing about one million steps a second, and can keep track of more than one operation because of this speed. One example you have already seen is that you can drive and steer the Robot (controlling two motors) at one time.

However, the possibilities are much greater than that. Through proper programming, you could take sonar readings while driving the Robot, and cut off the drive power if the Robot came too close to an obstruction. Similarly, you could employ two senses, switching quickly between one and the other so that it appeared that both were in constant operation. Remember that these abilities are commonplace to those with the skill at programming, and you can gain this skill by working with the Technical Manual. The following section lists a few more of the Robot's possibilities.

### PROGRAMMING POSSIBILITIES

The following is a small group of ideas that you may consider. These ideas are collected here for two purposes. First, they offer a realistic appraisal of some attainable Robot actions in case you wish to see what

# Heathkit®

---

more complex operations you could actually accomplish. Second, we hope that you will get excited about these ideas and begin to do your own programming. The Technical Manual and other booklets on machine language programming for the 6800 microprocessor will help you discover how to implement these programs and many others. Consider these possibilities:

— The Robot travels into a room, waits quietly for 30 seconds using the motion detector to see if there is anyone in the room. If there is, the Robot announces that supper is ready; if not, the Robot goes on its programmed course to another room, searching for someone to announce the meal to.

— The Robot stands in a room, sampling the amount of light in the room. In the evening when it gets dark, the Robot pulls a light cord, turning on a lamp. At 11:00 it pulls the cord again, turning off the lamp, and announces "Eleven o'clock, time for bed."

— The Robot waits at the end of a hall by the stairway up to the bedrooms. At night, it turns on its motion sensor. If it detects any motion, it rolls forward saying "Help, intruder! I have notified the police. Help, intruder! I have ...." It remembers the exact time of the disturbance, and only quiets down when you enter the correct code or when the motion detector remains undisturbed for 5 minutes.

— On Saturday morning, the Robot sits next to the television set. If the kids turn it up too loud, the Robot tells them, "The TV is too loud. Turn it down."

— The Robot listens as you clap your hands. Two claps mean to say "Welcome home, Master." Three claps mean to report, "I heard noise at 9:53 and 10:01." Four claps mean to roll forward, lift its arm, and say, "May I take your hat?"

— While you are gone for a weekend, the Robot wakes up four times each night, moves around and performs actions that give the appearance of someone present in the home. Potential burglars stay away.

— While the room is light, and when the Robot senses motion in the room, the Robot announces the time every fifteen minutes. In addition, it tells you to turn on the newscast at 6:58 PM.

— It's a weekday morning. Beginning at 6:35 AM, your Robot announces the time and tells you to get up. When it senses motion, it is quiet for two minutes. If the motion continues for three minutes, or if you press RESET, it remains quiet until the next day. If the motion stops the Robot begins again, telling you to get up. On Saturdays and Sundays, the Robot lets you sleep in peace.

— Your neighbor Herb comes over, asking about the new Robot. Herb opens the closet to hang up his sweater. The Robot is inside and senses that the door is open. It rolls forward saying, "Thank goodness someone finally let me out... Hi there, you must be Herb the neighbor. I'm Hero the Robot. Pleased to meet you." Then the Robot offers Herb a soft drink and ushers him into the den to his favorite chair.

## THE EXPERIMENTAL BOARD

In addition to the ABORT key and Sleep switch, the Experimental Board has a breadboard, that is important to the advanced hobbyist. The "breadboard" is available for creating circuitry that can interact with the Robot's computer. The breadboard has +12 and +5 volts, and ground, and also controls lines to and from the computer's CPU. More discussion of the Experimental Board is available in the Technical Manual.



## INDEX

- Abort Key, 15, 24, 27  
 Adjustments, Shoulder, 9  
 Adjustments, Speech, 34  
 Adjustments, Wrist, 7  
 Arm Homing, 17  
 Arm, Mounting and Adjusting, 9  
 Back Panel (see "Panels"), 6  
 Back-Up Feature, 24  
 Batteries  
     Installing, 9  
     Usage, 10  
 Cassette  
     Downloading To, 19  
     Uploading From, 19  
 Control Handle  
     (see "Teaching Pendant"), 21  
 Date  
     Display, 20  
     Set, 20  
 Display, 15  
 Executive Mode  
     (see "Modes of Operation"), 21  
 Experimental Board, 45  
 Factory Assembled Robot, 4  
 Front Panel (see "Panels"), 6  
 "FULL" display, 23  
 Function Switch, 21  
 Head Panel (see "Panels"), 5  
 Hexadecimal, 11, 21  
 Inflection (speech), 33, 34  
 Initializing, 17  
 Interrupt, 42  
 Keyboard, 14, 21  
 Keys, 14  
     A (AUTO/Repeat), 15, 24, 25  
     B (BACK), 24, 27  
     C (CHAN), 27  
     D (DO), 24, 32  
     E (EXAM), 26  
     F (FWD), 27  
     Multipurpose, 15  
     Numbered, 14, 15  
     RESET, 14, 15, 21, 26, 27  
 Learn Mode (see "Modes of Operation"), 23  
 Light Sensor  
     (see "Program Samples," or "Senses"), 39, 40  
 Lo Dr, 10  
 Lo Log, 10  
 "Machine" Language, 25  
 Memory Address, 23, 25, 26  
 Memory Considerations, 25  
 Memory, Saving in Learn Mode, 23  
 Maintenance, 13  
 Modes of Operation, 17  
     Executive, 21  
     Learn, 23  
     Manual, 21, 22  
     Program, 25, 26  
     Repeat, 24, 25  
     Utility, 17  
 Motion Detection;  
     (see "Program Samples," or "Senses"), 42  
 Motion Switch, 22  
 Panels, Removing or Installing, 5, 6  
 Pause, 29  
 Phoneme List, 31  
 Phrases in Memory, 38  
 Possibilities  
     (programs you might write), 44  
 Programming  
     Checking/Changing—Keyboard, 26  
     Checking/Changing—Learn Mode, 23, 24  
     Entering a Program, 26  
     Keyboard Entry, 26  
     Learn Mode Entry, 23  
     Possibilities, 44  
     Running a Program, 27, 32  
     Speech, 30, 38  
     Speech Inflection, 33, 34  
 Program Samples  
     Robot Movement, 27, 28  
     Light Sense, 40  
     Motion Detect, 42  
     Sound Sense, 41  
     Speech, 34-38  
     Ultrasonic Ranging, 43

- 
- Program Saving on a Cassette, 19
  - Removing Panels, 5, 6
  - "Robot" Language, 25, 28
  - Rotary Switch, 21
  - RTI, 24
  - Running a Program, 27, 32
  - Senses, 39
    - Light, 40
    - Motion, 42
    - Sound, 41
    - Time, 39
    - Ultrasonic Ranging, 43
  - Sleep Operation, 44
  - Sleep Switch, 12, 15, 44
  - Speech, 30, 32, 34
  - Subroutine, 29
  - Teaching Pendant, 21, 23
  - Time, 39
    - Display, 20
    - Set, 20
  - Trigger Switch, 21
  - Turning the Robot ON, 12
  - Ultrasonic Ranging, 43
  - Wrist Rotation, 7

# CUSTOMER SERVICE

## REPLACEMENT PARTS

Please provide complete information when you request replacements from either the factory or Heath/Zenith Computers and Electronics Centers. Be certain to include the **HEATH** part number exactly as it appears in the parts list.

### ORDERING FROM THE FACTORY

Print all of the information requested on the parts order form furnished with this product and mail it to Heath. For telephone orders (parts only) dial 616 982-3571. If you are unable to locate an order form, write us a letter or card including.

- Heath part number.
- Model number.
- Date of purchase.
- Location purchased or invoice number.
- Nature of the defect.
- Your payment or authorization for COD shipment of parts not covered by warranty.

Mail letters to: Heath Company  
Benton Harbor  
MI 49022  
Attn: Parts Replacement

**Retain original parts until you receive replacements. Parts that should be returned to the factory will be listed on your packing slip.**

### OBTAINING REPLACEMENTS FROM HEATH/ZENITH COMPUTERS AND ELECTRONICS CENTERS

For your convenience, "over the counter" replacement parts are available from the Heath/Zenith Computers and Electronics Centers listed in your catalog. Be sure to bring in the original part and purchase invoice when you request a warranty replacement from a Heath/Zenith Computers and Electronics Centers.

## TECHNICAL CONSULTATION

Need help with your kit? — Self-Service? — Construction? — Operation? — Call or write for assistance; you'll find our Technical Consultants eager to help with just about any technical problem except "customizing" for unique applications.

The effectiveness of our consultants service depends on the information you furnish. Be sure to tell us:

- The Model number and Series number from the blue and white label.
- The date of purchase.
- An exact description of the difficulty.
- Everything you have done in attempting to correct the problem.

Also include switch positions, connections to other units, operating procedures, voltage readings, and any other information you think might be helpful.

**Please do not send parts for testing,** unless this is specifically requested by our Consultants.

Hints: Telephone traffic is lightest at midweek — please be sure your Manual and notes are on hand when you call.

Heath/Zenith Computers and Electronics Centers facilities are also available for telephone or "walk-in" personal assistance.

## REPAIR SERVICE

Service facilities are available, if they are needed, to repair any portions of your Robot that need service. (Kits that have been modified, soldered with paste flux or acid core solder, cannot be accepted for repair.) Identify the questionable area by using the "Troubleshooting" section of your Technical Manual and Heath's Technical Consultants (if necessary), then return only the questionable portion for service. Never send a complete Robot unless you are instructed to do so by a Technical Consultant.

**If it is convenient, deliver the questionable portion personally to a Heath/Zenith Computers and Electronics Centers. For warranty parts replacement, supply a copy of the invoice or sales slip.**

If you should need to ship some portion of the Robot to the factory, attach a letter containing the following information directly to that portion of the Robot:

- Your name and address.
- Date of purchase and invoice number.
- Copies of all correspondence relevant to the service of the kit.
- A brief description of the difficulty.
- Authorization to return your kit COD for the service and shipping charges. (This will reduce the possibility of delay.)

Package any portions of the Robot that you wish to ship in a strong carton with at least THREE INCHES of resilient packing material (shredded paper, excelsior, etc.) on all sides. Contact the Heath Company for instructions for sending the entire Robot or large portions of it.

Seal the carton with reinforced gummed tape, and mark it "Fragile" on at least two sides. Remember, the carrier will not accept liability for shipping damage if the unit is insufficiently packed. Ship by prepaid express, United Parcel Service, or insured Parcel Post to:

Heath Company  
Service Department  
Benton Harbor, Michigan 49022

595-3070-01