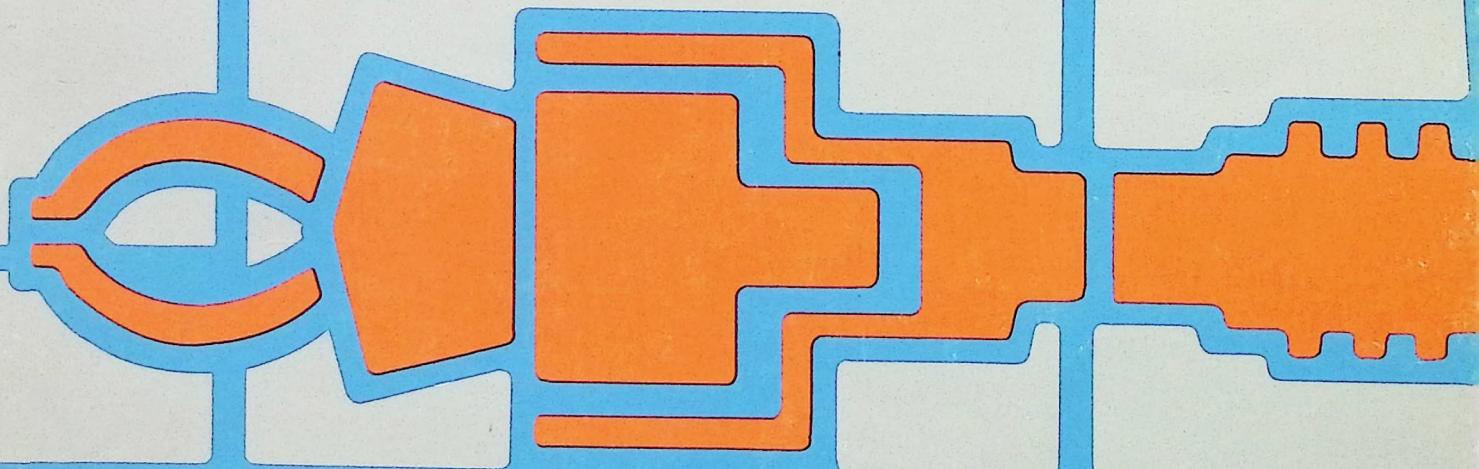


# ET-18 ROBOT ARM MANUAL



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 12 P.M. and 1:00 P.M. to 4:30 P.M., EST, Weekdays Only*

|  |                |
|--|----------------|
| R/C, Audio, and Electronic Organs .....  | (616) 982-3310 |
| Amateur Radio .....  | (616) 982-3296 |
| Test Equipment, Weather Instruments and<br>Home Clocks .....                               | (616) 982-3315 |
| Television .....   | (616) 982-3307 |
| Aircraft, Marine, Security, Scanners, Automotive,<br>Appliances and General Products ..... | (616) 982-3496 |
| Computers — Hardware .....   | (616) 982-3309 |
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| Application Programs .....   | (616) 982-3884 |
| Heath Craft Wood Works .....   | (616) 982-3423 |

## 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 Heathkit Electronic Center (units of Ventechnology 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-18-1**

**Arm Accessory Manual**

**595-2886-04**

**HEATH COMPANY  
BENTON HARBOR, MICHIGAN 49022**

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## INTRODUCTION

Your ET-18-1 Accessory Robot Arm is just what your ET-18 Hero Robot needs; an arm that can manipulate various objects and perform all those intricate tasks that you will soon be giving it. This will open up a whole new dimension of challenging, learning and entertainment applications for your Hero Robot.

The Robot Arm has seven axies of movement which are controlled by the robot's CPU (central processor unit). You can program the Arm through the robot's

hexadecimal keyboard, or by use of the teaching pendant. Since all of the Arm's movement is controlled by stepper motors, it is capable of performing complex repetitive tasks with little cumulative error.

The Robot Arm is a rewarding kit to build with several of the necessary tools already supplied. Its careful design will provide you with many hours of enjoyable performance.

## UNPACKING INSTRUCTIONS

**Do not unpack your kit until you are instructed to do so.**

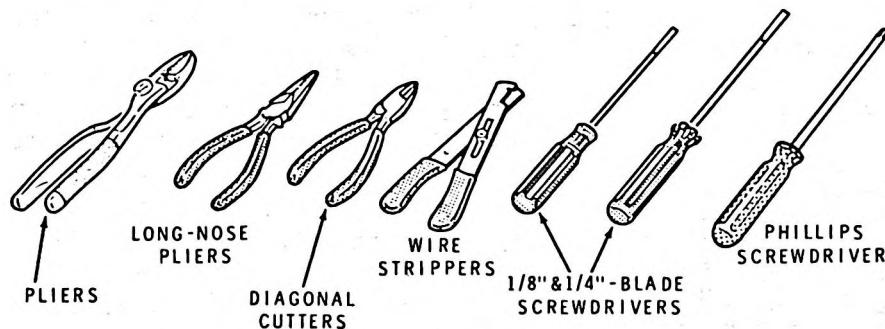
The Robot Arm Accessory is packed in one carton that contains an upper and a lower section. Pack #1 is located in the upper section. Do not remove any parts from the carton until they are specifically called for by a Parts List in this Manual.

After you have removed Pack #1, the remaining parts will be considered the "final pack." The final pack contains several large parts, some of which are wrapped. An instruction at the beginning of each Parts List tells you which pack to open.

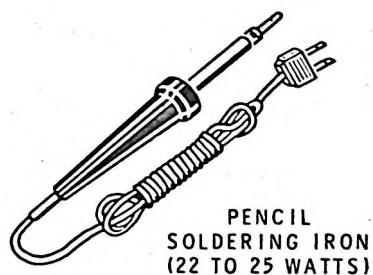
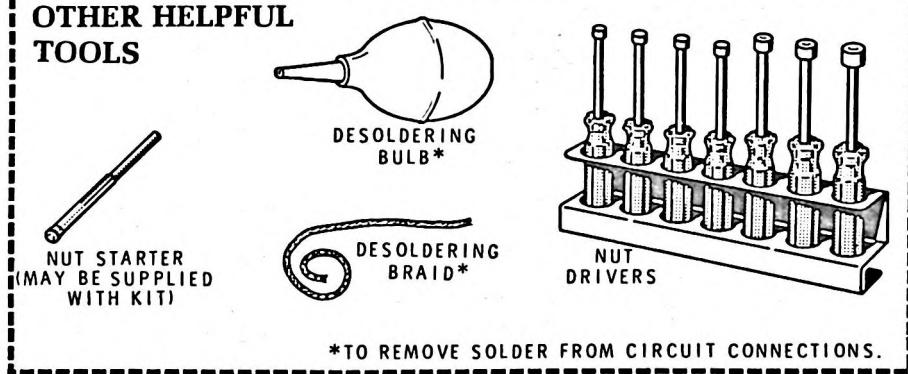
# ASSEMBLY NOTES

## TOOLS

You will need these tools to assemble your kit.



### OTHER HELPFUL TOOLS



## ASSEMBLY

1. Follow the instructions carefully. Read the entire step before you perform each operation.
2. The illustrations in the Manual are called Pictorials and Details. Pictorials show the overall operation for a group of assembly steps; Details generally illustrate a single step. When you are directed to refer to a certain Pictorial "for the following steps," continue using that Pictorial until you are referred to another Pictorial for another group of steps.
3. Most kits use a separate "Illustration Booklet" that contains illustrations (Pictorials, Details, etc.) that are too large for the Assembly Manual. Keep the "Illustration Booklet" with the Assembly Manual. The illustrations in it are arranged in Pictorial number sequence.
4. Position all parts as shown in the Pictorials.
5. Solder a part or a group of parts only when you are instructed to do so.

6. Each circuit part in an electronic kit has its own component number (R2, C4, etc.). Use these numbers when you want to identify the same part in the various sections of the Manual. These numbers, which are especially useful if a part has to be replaced, appear:
  - In the Parts List,
  - At the beginning of each step where a component is installed,
  - In some illustrations,
  - In the Schematic,
  - In the section at the rear of the Manual.
7. When you are instructed to cut something to a particular length, use the scales (rulers) provided at the bottom of the Manual pages.

**SAFETY WARNING:** Avoid eye injury when you cut off excessive lead lengths. Hold the leads so they cannot fly toward your eyes.

## SOLDERING

Soldering is one of the most important operations you will perform while assembling your kit. A good solder connection will form an electrical connection between two parts, such as a component lead and a circuit board foil. A bad solder connection could prevent an otherwise well-assembled kit from operating properly.

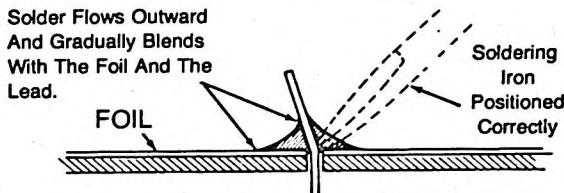
It is easy to make a good solder connection if you follow a few simple rules:

1. Use the right type of soldering iron. A 22 to 25-watt pencil soldering iron with a 1/8" or 3/16" chisel or pyramid tip works best.
2. Keep the soldering iron tip clean. Wipe it often on a wet sponge or cloth; then apply solder to the tip to give the entire tip a wet look. This process is called tinning, and it will protect the tip and enable you to make good connections. When solder tends to "ball" or does not stick to the tip, the tip needs to be cleaned and retinned.

NOTE: Always use rosin core, radio-type solder (60:40 tin-lead content) for all of the soldering in this kit. This is the type we have supplied with the parts. The Warranty will be void and we will not service any kit in which acid core solder or paste has been used.

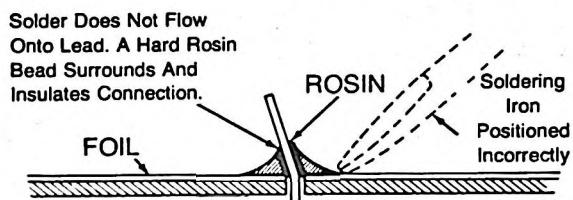
# Heathkit®

## A GOOD SOLDER CONNECTION

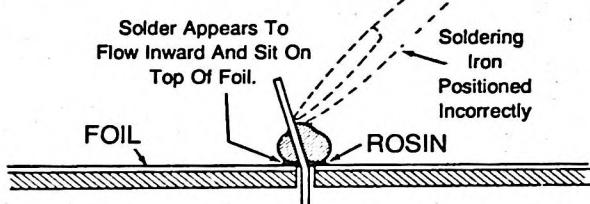


When you heat the lead and the circuit board foil at the same time, the solder will flow evenly onto the lead and the foil. The solder will make a good electrical connection between the lead and the foil.

## POOR SOLDER CONNECTIONS



When the lead is not heated sufficiently, the solder will not flow onto the lead as shown above. To correct, reheat the connection and, if necessary, apply a small amount of additional solder to obtain a good connection.

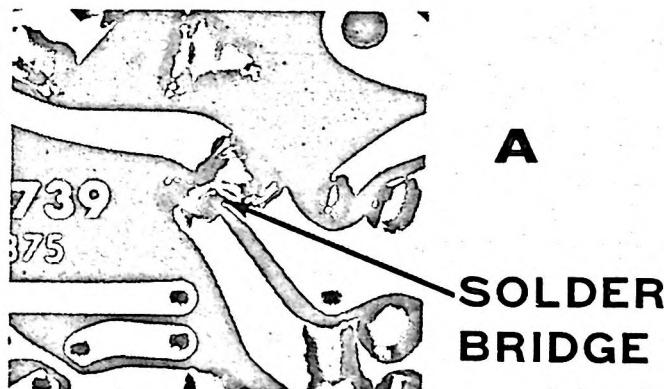


When the foil is not heated sufficiently the solder will blob on the circuit board as shown above. To correct, reheat the connection and, if necessary, apply a small amount of additional solder to obtain a good connection.

## SOLDER BRIDGES

A solder bridge between two adjacent foils is shown in photograph A. Photograph B shows how the connection should appear. A solder bridge may occur if you accidentally touch an adjacent previously soldered connection, if you use too much solder, or if you "drag" the soldering iron across other foils as you remove it from the connection. A good rule to follow is: always take a good look at the foil area around each lead before you solder it. Then, when you solder the connection, make sure the solder remains in this area and does not bridge to another foil. This is especially important when the foils are small and close together. NOTE: It is alright for solder to bridge two connections on the same foil.

Use only enough solder to make a good connection, and lift the soldering iron straight up from the circuit board. If a solder bridge should develop, turn the circuit board foil-side-down and heat the solder between connections. The excess solder will run onto the tip of the soldering iron, and this will remove the solder bridge. NOTE: The foil side of most circuit boards has a coating on it called "solder resist." This is a protective insulation to help prevent solder bridges.



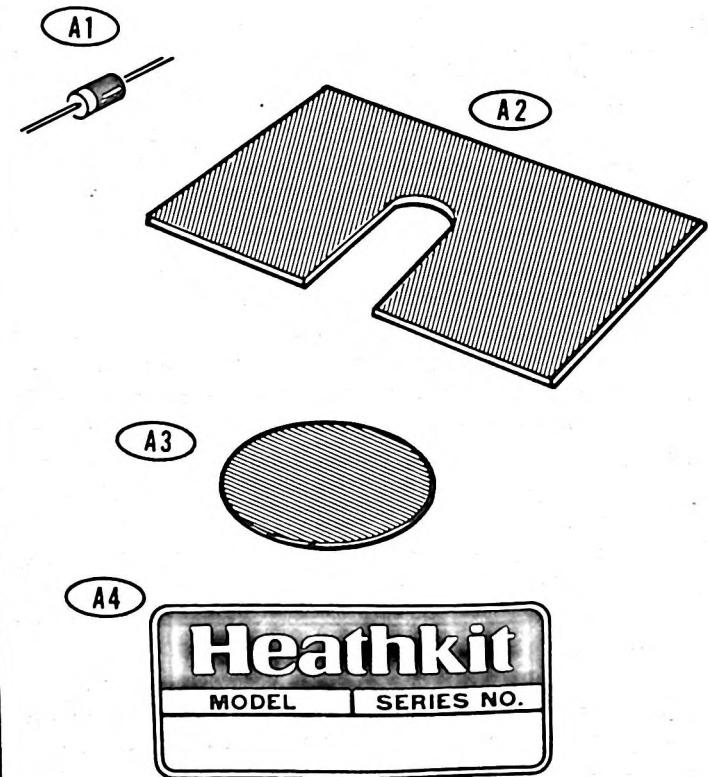
# WRIST/SHOULDER CIRCUIT BOARD

## PARTS LIST

Refer to the "Pack Index Sheet" and locate Pack #1. Then remove it and check each part against the following list and the "Wrist/Shoulder Circuit Board Parts Pictorial." The key numbers correspond to the numbers on the "Parts Pictorial." Return any part that is packed in an individual envelope, with the part number on it, back into its envelope until that part is called for in a step. Do not throw away any packing material until you account for all the parts.

To order a replacement part, always include the PART NUMBER. Use the Parts Order Form furnished with this kit. If a Parts Order Form is not available, refer to "Replacement Parts" inside the rear cover of this Manual. For prices, refer to the separate "Heath Parts Price List."

| KEY | HEATH<br>No. | QTY. | DESCRIPTION                                     | CIRCUIT<br>Comp. No.   |
|-----|--------------|------|---|--|
| A1  | 57-65        | 20   | 1N4002 diode                                    | D1 through D8 for shoulder board.<br>D1 through D13 for wrist board. |
| A2  | 85-2695-1    | 2    | Wrist/Shoulder circuit board                    |  |
| A2  | 390-2319     | 1    | Decorative label*                               |  |
| A3  | 390-2324     | 1    | Round decorative label*                         |  |
| A4  |              | 1    | Blue and white label*                           |  |
|     |              | 1    | Assembly Manual (see Page 1<br>for part number) |  |
|     | 597-260      | 1    | Parts Order Form<br>Solder                      |  |



\*Located inside the Assembly Manual.

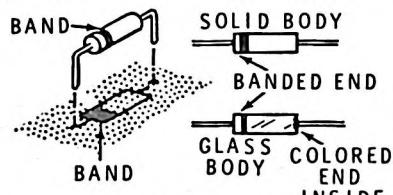
## STEP-BY-STEP ASSEMBLY

## SHOULDER CIRCUIT BOARD

## START →

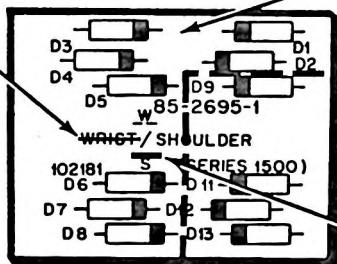
- ( ) Use a felt-tip pen to cross out the word "WRIST" on one of the Wrist Shoulder circuit boards. Then position this "Shoulder" circuit board as shown.

NOTE: When you install diodes, as in the following steps, always match the band on the diode with the band mark on the circuit board. THE CIRCUIT WILL NOT WORK PROPERLY IF A DIODE IS INSTALLED BACKWARD.



CAUTION: ALWAYS POSITION THE BANDED END OF A DIODE AS SHOWN ON THE CIRCUIT BOARD.

If your diode has a solid body, the banded end is easily identified. If your diode has a glass body, do not mistake the colored end INSIDE the diode for the banded end. Look for a band painted on the OUTSIDE of the glass.



## CONTINUE ↘

Install 1N4002 diodes (#57-65) at the following eight locations:

- |        |        |
|--------|--------|
| ( ) D1 | ( ) D5 |
| ( ) D2 | ( ) D6 |
| ( ) D3 | ( ) D7 |
| ( ) D4 | ( ) D8 |

- ( ) Solder the leads to the foil and cut off the excess lead lengths. NOTE: Save one of the cutoff leads.

- ( ) Form the saved cutoff diode lead into a "U". Install this "U" over the "S" on the circuit board and solder it to the foils. Cut off the excess wire lengths.

- ( ) Perform the "Circuit Board Checkout" below. Then set the circuit board aside and proceed with the "Wrist Circuit Board" assembly.

## PICTORIAL 1-1

## CONTINUE ↘

- ( ) Form the saved cutoff diode lead into a "U". Install this "U" over the "W" on the circuit board and solder it to the foils. Cut off the excess wire lengths.

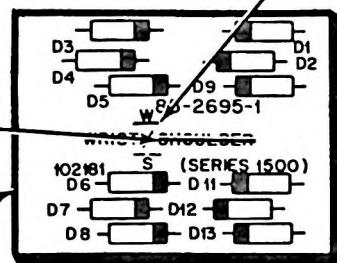
## CIRCUIT BOARD CHECKOUT

Carefully examine the circuit board to be sure all diodes are installed with their banded ends over the band marks on the circuit board. There should be no diodes installed at D9 through D13 on the shoulder board.

Check to see that the jumper wire (cutoff diode lead) is installed over the "S" on the Shoulder Board (over the "W" on the Wrist Board).

Examine the foil side of the circuit board to see that all leads are properly soldered, and there are no solder bridges between circuit board foils.

Set the circuit board aside until it is called for later.



## PICTORIAL 1-2

## WRIST CIRCUIT BOARD

## START →

- ( ) Use a felt-tip pen to cross out the word "SHOULDER" on one of the Wrist/Shoulder circuit boards. Then position this "Wrist" circuit board as shown.

NOTE: In the following steps, remember to match the banded ends of the diodes with the band marks on the circuit board.

Install 1N4002 diodes (#57-65) at the following twelve locations:

- |        |        |         |
|--------|--------|---------|
| ( ) D1 | ( ) D5 | ( ) D9  |
| ( ) D2 | ( ) D6 | ( ) D11 |
| ( ) D3 | ( ) D7 | ( ) D12 |
| ( ) D4 | ( ) D8 | ( ) D13 |

- ( ) Solder the leads to the foil and cut off the excess lead lengths. NOTE: Save one of the cutoff diode leads.

## FINISH



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# ARM

## PARTS LIST

Remove the remaining parts from the carton and check each part against the following list and the "Arm Parts Pictorial (Illustration Booklet, Pages 1-3)." The key numbers correspond to the numbers on the "Parts Pictorial." Return any part that is packed in an individual envelope, with the part number on it, back into its envelope until that part is called for in a step. Do not throw away any packing material until you account for all the parts.

| KEY<br>No. | HEATH<br>Part No. | QTY. | DESCRIPTION |
|------------|-------------------|------|-------------|
|------------|-------------------|------|-------------|

### PLASTIC—NYLON—RUBBER PARTS

|     |          |   |                                 |
|-----|----------|---|---------------------------------|
|     | 305-116  | 1 | Molded arm set,<br>consists of: |
| A1  | 92-757   | 1 | Circuit board cover             |
| A2  | 204-2595 | 1 | Gripper bracket                 |
| A3  | 204-2596 | 1 | Wrist bracket                   |
| A4  | 214-234  | 1 | Motor housing top               |
| A5  | 214-244  | 1 | Motor housing bottom            |
| A6  | 214-236  | 1 | Wrist rotate motor cover        |
| A7  | 485-40   | 1 | Shoulder plug                   |
| A8  | 92-756   | 1 | Arm shell (curved track)        |
| A9  | 92-782   | 1 | Arm shell (straight track)      |
| A10 | 94-634   | 1 | Bellows                         |
| A11 | 207-18   | 1 | Cable clamp                     |
| A12 | 451-615  | 1 | Worm                            |
| A13 | 451-616  | 1 | Worm gear                       |
| A14 | 266-1197 | 2 | Gripper                         |
| A15 | 266-1199 | 1 | Threaded rod                    |
| A16 | 354-7    | 3 | Cable tie                       |
| A17 | 253-28   | 1 | Rubber "O" ring                 |
| A18 | 490-5    | 1 | Plastic nut starter             |
| A19 | 253-744  | 2 | Plastic flat washer             |

To order a replacement part, always include the PART NUMBER. Use the Parts Order Form furnished with this kit. If a Parts Order Form is not available, refer to "Replacement Parts" inside the rear cover of this Manual. For prices, refer to the separate "Heath Parts Price List."

| KEY<br>No. | HEATH<br>Part No. | QTY. | DESCRIPTION |
|------------|-------------------|------|-------------|
|------------|-------------------|------|-------------|

### HARDWARE

NOTE: The hardware is shown full size so you can place any nut, screw, etc. you are uncertain about over the drawing. Also, the hardware may be packed in more than one packet. Open all the hardware packets (marked HDW) before you check the hardware against the Parts List.

#### #1 and #2 Hardware

|    |          |   |                            |
|----|----------|---|----------------------------|
| B1 | 250-536  | 2 | 1-72 × 1/8" screw          |
| B2 | 250-1446 | 1 | 2-56 × 1/8" allen setscrew |

#### #4 Hardware

|    |          |   |                                 |
|----|----------|---|---------------------------------|
| C1 | 250-1447 | 1 | 4-40 × 13/16" allen<br>setscrew |
|----|----------|---|---------------------------------|

| KEY<br>No. | HEATH<br>Part No. | QTY. | DESCRIPTION | CIRCUIT<br>Comp. No. |
|------------|-------------------|------|-------------|----------------------|
|------------|-------------------|------|-------------|----------------------|

**#4 Hardware (Cont'd)**

|     |          |   |   |  |
|-----|----------|---|---|--|
| C2  | 250-1445 | 3 | 4-40 x 3/16" black phillips head screw      |  |
| C3  | 250-1455 | 2 | 4-40 x 3/16" black phillips flat head screw |  |
| C4  | 250-1411 | 4 | 4-40 x 1/4" black phillips head screw       |  |
| C5  | 250-1450 | 2 | 4-40 x 5/16" black phillips flat head screw |  |
| C6  | 250-1412 | 2 | 4-40 x 3/8" black phillips head screw       |  |
| C7  | 250-1454 | 1 | 4-40 x 7/16" black phillips flat head screw |  |
| C8  | 250-389  | 4 | 4-40 x 3/4" black screw                     |  |
| C9  | 252-2    | 9 | 4-40 x 1/4" nut                             |  |
| C10 | 252-135  | 1 | 4-40 locknut                                |  |
| C11 | 252-731  | 3 | 4-40 brass insert                           |  |
| C12 | 254-9    | 3 | #4 lockwasher                               |  |
| C13 | 255-757  | 2 | 4-40 x 3/16" hex spacer                     |  |
| C14 | 255-802  | 1 | 4-40 x 3/8" shoulder spacer                 |  |
| C15 | 255-29   | 2 | 4-40 x 7/32" round spacer                   |  |
| C16 | 255-777  | 2 | 4-40 x 9/32" round threaded spacer          |  |
| C17 | 255-799  | 1 | 4-40 x 15/32" round threaded spacer         |  |
| C18 | 255-195  | 2 | 4-40 x 3/8" hex spacer                      |  |
| C19 | 255-801  | 1 | 4-40 x 9/16" round spacer                   |  |
| C20 | 250-1456 | 1 | 4-40 x 5/16" allen setscrew                 |  |
| C21 | 250-1484 | 1 | 4-40 x 1/8" black allen setscrew            |  |

**#6 Hardware**

|     |          |    |  |  |
|-----|----------|----|--|--|
| D1  | 250-1282 | 2  | 6-32 x 1/8" black allen setscrew           |  |
| D2  | 250-1419 | 1  | 6-32 x 1/4" black phillips flat head screw |  |
| D3  | 250-1280 | 18 | 6-32 x 3/8" black phillips head screw      |  |
| D4  | 252-122  | 15 | 6-32 black nut                             |  |
| D5  | 253-1    | 2  | #6 flat fiber washer                       |  |
| D6  | 253-2    | 2  | #6 fiber shoulder washer                   |  |
| D7  | 253-89   | 1  | #6 D-washer                                |  |
| D8  | 254-1    | 5  | #6 lockwasher                              |  |
| D9  | 254-6    | 1  | #6 external tooth lockwasher               |  |
| D10 | 255-800  | 1  | 6-32 x 5/16" black threaded spacer         |  |
| D11 | 255-83   | 2  | 6-32 x 11/16" threaded spacer              |  |
| D12 | 255-103  | 2  | 6-32 x 11/32" threaded spacer              |  |

**#8 Hardware**

|    |        |   |                            |  |
|----|--------|---|----------------------------|--|
| E1 | 250-93 | 3 | 8-32 x 1/4" allen setscrew |  |
| E2 | 259-2  | 2 | #8 solder lug              |  |
| E3 | 259-24 | 1 | #8 long solder lug         |  |

| KEY<br>No. | HEATH<br>Part No. | QTY. | DESCRIPTION | CIRCUIT<br>Comp. No. |
|------------|-------------------|------|-------------|----------------------|
|------------|-------------------|------|-------------|----------------------|

| KEY<br>No. | HEATH<br>Part No. | QTY. | DESCRIPTION | CIRCUIT<br>Comp. No. |
|------------|-------------------|------|-------------|----------------------|
|------------|-------------------|------|-------------|----------------------|

**Other Hardware**

|     |         |   |                    |  |
|-----|---------|---|--------------------|--|
| F1  | 252-5   | 4 | 10-32 nut          |  |
| F2  | 254-3   | 4 | #10 lockwasher     |  |
| F3  | 252-101 | 3 | 5/16" nut          |  |
| F4  | 253-86  | 1 | 9/16" flat washer  |  |
| F5  | 253-31  | 1 | 3/4" flat washer   |  |
| F6  | 253-167 | 1 | Teflon® washer     |  |
| F7  | 254-15  | 1 | Control lockwasher |  |
| F8  | 258-6   | 1 | Actuator           |  |
| F9  | 253-11  | 1 | E-ring             |  |
| F10 | 456-7   | 1 | Coupler            |  |

**BRACKETS — PLATE — TUBING**

|    |            |   |                        |
|----|------------|---|------------------------|
| G1 | 204-2648   | 1 | Arm mounting bracket   |
| G2 | 204-2594   | 1 | Actuator bracket       |
| G3 | 205-1879-1 | 2 | Cover plate            |
| G4 | 267-18-1   | 1 | Motor mounting bracket |
| G5 | 267-19-1   | 1 | Wrist mounting bracket |
| G6 | 266-1198   | 1 | Tubing                 |

**SLEEVING — CABLE**

|        |        |                          |
|--------|--------|--------------------------|
| 346-29 | 9"     | Clear sleeving           |
| 346-20 | 2-1/2" | Heat-shrinkable sleeving |
| 346-81 | 2'     | Flexible sleeving        |
| 347-55 | 3'     | Flat 8-wire cable        |
| 347-87 | 1      | 10-wire spiral cable     |
| 346-46 | 6"     | Black sleeveing          |

**MOTORS**

|    |         |   |              |    |
|----|---------|---|--------------|----|
| H1 | 420-624 | 1 | Gripper      | A6 |
| H2 | 420-626 | 1 | Wrist rotate | A7 |
| H3 | 420-625 | 1 | Wrist pivot  | A8 |
| H4 | 420-642 | 1 | Shoulder     | A4 |
| H5 | 420-631 | 1 | Arm extend   | A5 |

**CONNECTORS**

|    |         |    |               |       |
|----|---------|----|---------------|-------|
| J1 | 432-146 | 1  | 15-pin male   | P1501 |
| J2 | 432-702 | 1  | 24-pin female | S1502 |
| J3 | 432-704 | 1  | 24-pin male   | P1502 |
| J4 | 432-854 | 20 | Male pin      |       |
| J5 | 432-855 | 32 | Female pin    |       |

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| KEY | HEATH    | QTY. | DESCRIPTION |
|-----|----------|------|-------------|
| No. | Part No. |      |             |

### SHAFTS — BEARINGS — BUSHINGS

|     |         |   |                                 |
|-----|---------|---|---------------------------------|
| K1  | 453-332 | 1 | Wrist pivot shaft               |
| K2  | 453-333 | 1 | Worm shaft                      |
| K3  | 453-341 | 1 | Gripper rotate shaft            |
| K4  | 453-337 | 2 | Gripper pivot shaft             |
| K5  | 455-638 | 1 | Teflon* bearing                 |
| K6  | 455-659 | 1 | Threaded arm bushing            |
| K7  | 455-660 | 1 | Hex shoulder bushing            |
| K8  | 455-661 | 1 | Worm gear bearing               |
| K9  | 455-662 | 1 | Wrist drive bushing             |
| K10 | 455-663 | 1 | Round bushing                   |
| K11 | 455-664 | 1 | Round brass<br>shoulder bushing |
| K12 | 455-665 | 1 | 7/8" brass bushing              |
| K13 | 455-666 | 1 | 1/4" bushing                    |

| KEY | HEATH    | QTY. | DESCRIPTION |
|-----|----------|------|-------------|
| No. | Part No. |      |             |

### MISCELLANEOUS

|    |         |    |                  |
|----|---------|----|------------------|
| L1 | 73-39   | 1' | 1/4" foam tape   |
| L2 | 352-14  | 2  | Grease           |
| L3 | 352-33  | 1  | Vibra-Tite**     |
| L4 | 490-6   | 1  | #8 allen wrench  |
| L4 | 490-23  | 1  | #4 allen wrench  |
| L4 | 490-173 | 1  | #2 allen wrench  |
| L4 | 490-14  | 1  | #6 allen wrench  |
| L5 | 490-98  | 1  | 3/16" nut driver |

## STEP-BY-STEP ASSEMBLY

### ARM BRACKET ASSEMBLY

Refer to Pictorial 2-1 for the following steps.

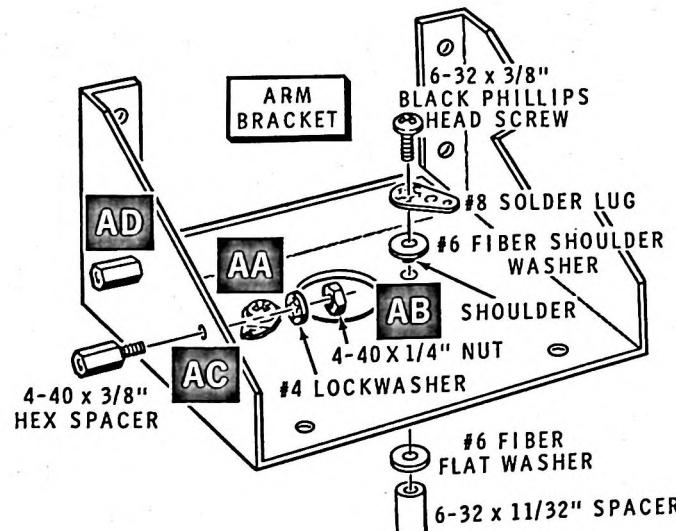
- ( ) Position the arm bracket as shown.

**NOTE:** Many steps that require hardware only call out the screw size. For example, when a step calls for "6-32 x 3/8" black phillips-head hardware," it means you should use (at each mounting location) a 6-32 x 3/8" black phillips-head screw, one or more #6 lockwashers (or a solder lug), and a 6-32 nut. The Detail or Pictorial referred to in the step shows the proper number and use of the hardware.

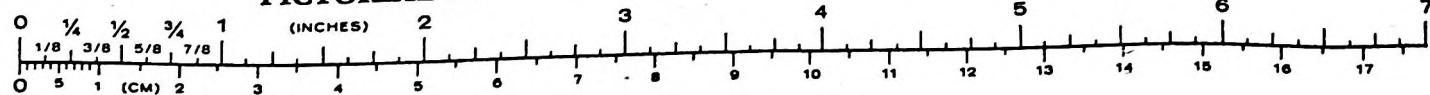
- ( ) Mount 6-32 x 11/32" spacers at AA and AB with 6-32 x 3/8" black phillips head screws, #8 solder lugs, #6 flat fiber washers, and #6 fiber shoulder washers. Position the solder lugs as shown and then bend the lugs down slightly after you tighten the screws. Also, make sure the shoulder of each shoulder washer seats into its hole.

**NOTE:** Use the nut starter supplied with this kit to hold and start 4-40 and 6-32 nuts on screws.

- ( ) Mount 4-40 x 3/8" hex spacers at AC and AD with #4 lockwashers and 4-40 nuts.



**PICTORIAL 2-1**



Refer to Pictorial 2-2 (Illustration Booklet, Page 3) for the following steps.

- ( ) Cut the following lengths of flat 8-wire cable:

Three 9"  
One 5-1/2"

- ( ) Refer to Detail 2-2A (Illustration Booklet, Page 4) and separate the following wires, as a group, from two of the 9" flat 8-wire cables. Use a pair of cutters or a knife to start separating the wires. See the inset drawing.

- One brown, red, and orange 3-wire cable from one of the 9" cables.
- One green, blue, violet, and gray 4-wire cable from the same 9" cable. Discard the yellow wire from this cable.
- One brown and red 2-wire cable from the second 9" cable.
- One orange and yellow 2-wire cable from the same 9" cable.
- Discard the remaining green, blue, violet, and gray wires from this cable.

- ( ) Cut the 9" brown and red 2-wire cable to 5-1/2". Set the 5-1/2" cable aside.

- ( ) Remove the red wire from the remaining 3-1/2" brown and red cable and cut the red wire to 3". Set the red wire aside and discard the brown wire.

**NOTE:** In the following steps, you will prepare the cable wires. To prepare a wire, remove 1/8" of insulation from both ends. Twist the fine wire strands tightly together at each end and apply a small amount of solder to hold the strands in place.

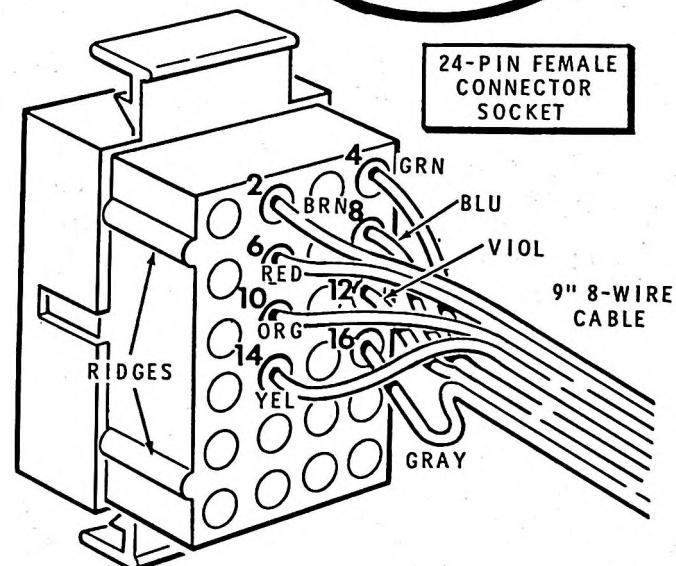
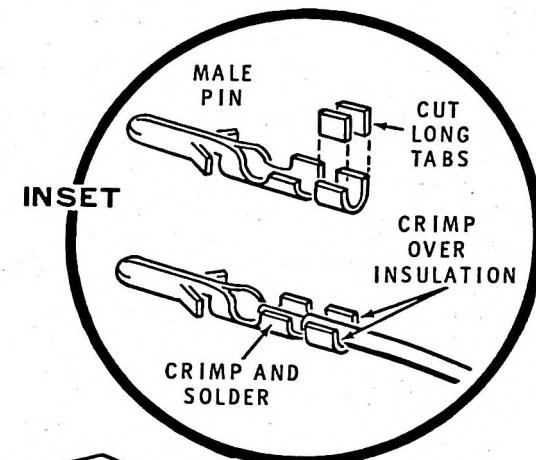
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- ( ) Refer to Part A of Detail 2-2B (Illustration Booklet, Page 4) and separate one end of the 9" orange and yellow 2-wire cable for a distance of 3-1/2", and separate the other end for a distance of 1". Then prepare the wire ends.
- ( ) Refer to Part B of Detail 2-2B (Illustration Booklet, Page 4) and separate the ends of the remaining cables as shown. Then prepare the wire ends.
- ( ) Refer to the inset drawing in Detail 2-2C and crimp and solder male pins on the ends of the 1" separated wires of the 9" 8-wire cable. Cut the long tabs on each of the male pins to the same length as the shorter tabs. This will make it easier to crimp the tabs around the thin wire insulation.
- ( ) Similarly crimp and solder male pins on the ends of the 1" separated wires of the 9" 4-wire cable.
- ( ) Similarly crimp and solder male pins on the ends of the 1" separated wires of the 9" 2-wire cable.
- ( ) Crimp and solder male pins on the ends of the 1" separated **brown** and **orange** wires of the 9" 3-wire cable. You will install a male pin on the **red** wire later.

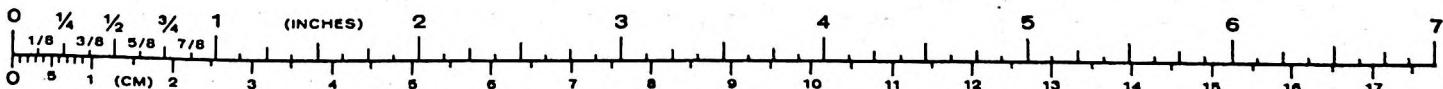
**NOTE:** You will install the male pins into the 24-pin female connector socket holes in the following steps. Since the pins are virtually impossible to remove once they are installed, without being destroyed, make sure you install each color wire at its proper socket hole number location. Partially insert the cable wire pins from each cable into their designated socket holes; then check to make sure they are correctly located. After that, press each pin as far as possible into its hole. You will hear a faint latching "click" as the pin locks into place.

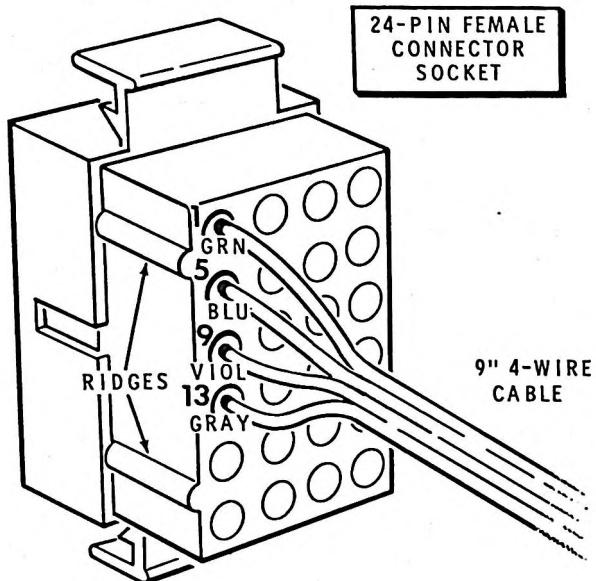
Refer to Detail 2-2C and position the 24-pin female connector socket with the ridges as shown. Then insert the male pins on the end of the 9" 8-wire cable into the 24-pin female connector socket as follows:

- ( ) Brown wire at hole 2.
- ( ) Red wire at hole 6.
- ( ) Orange wire at hole 10.
- ( ) Yellow wire at hole 14.
- ( ) Green wire at hole 4.
- ( ) Blue wire at hole 8.
- ( ) Violet wire at hole 12.
- ( ) Gray wire at hole 16.



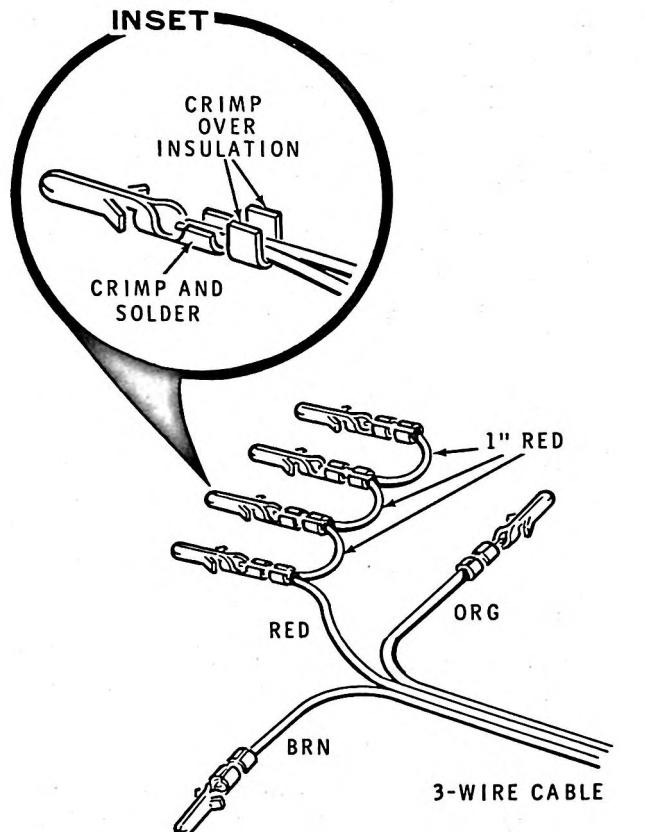
Detail 2-2C



**Detail 2-2D**

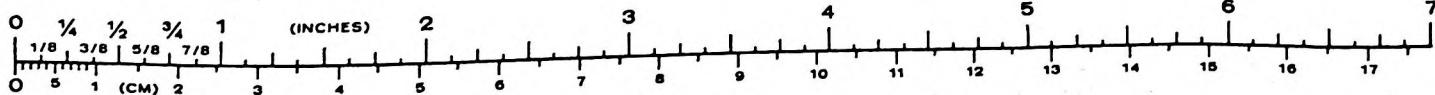
Refer to Detail 2-2D and insert the male pins on the end of the 9" 4-wire cable into the 24-pin female connector socket as follows:

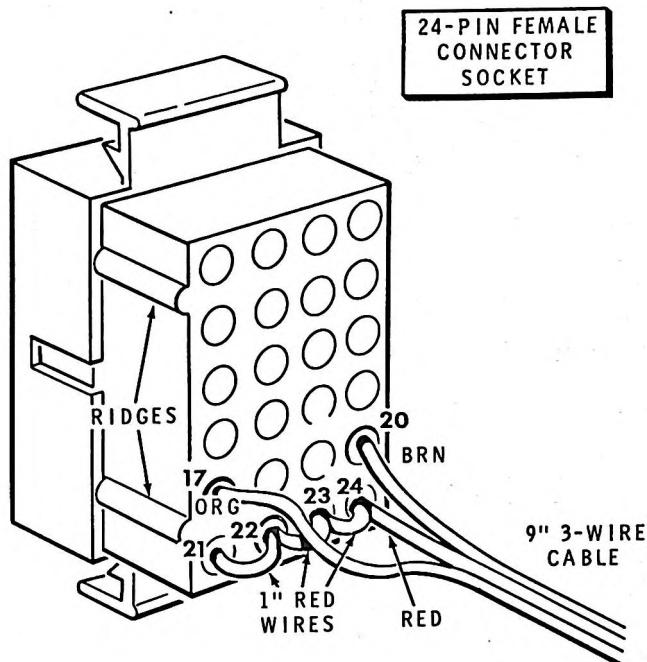
- ( ) Green wire at hole 1.
- ( ) Blue wire at hole 5.
- ( ) Violet wire at hole 9.
- ( ) Gray wire at hole 13.
- ( ) Cut the 3" red wire you set aside earlier into three 1" pieces and prepare the ends to 1/8".
- ( ) Refer to Detail 2-2E and crimp and solder male pins on ends of the red wire from the 3-wire cable and the three 1" red wires. Combine the wires in each male pin as shown in the inset drawing. Do not trim the tabs on these pins.

**Detail 2-2E**

Refer to Detail 2-2F and insert the male pins on the end of the 9" 3-wire cable into the 24-pin female connector socket as follows:

- ( ) Brown wire at hole 20.
- ( ) Orange wire at hole 17.
- ( ) Red wire from 3-wire cable at hole 24.
- ( ) Remaining 1" red wires into holes 23, 22, and 21. Insert the male pins on these wires in the sequence shown in the Detail.
- ( ) Set the 24-hole female connector socket assembly and the remaining orange and yellow 2-wire cable aside.



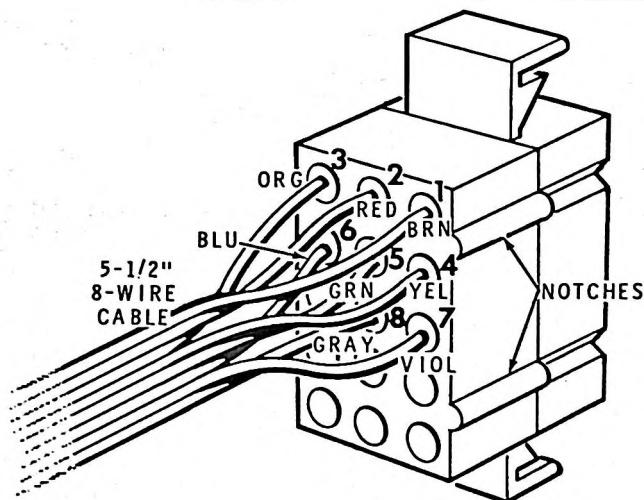
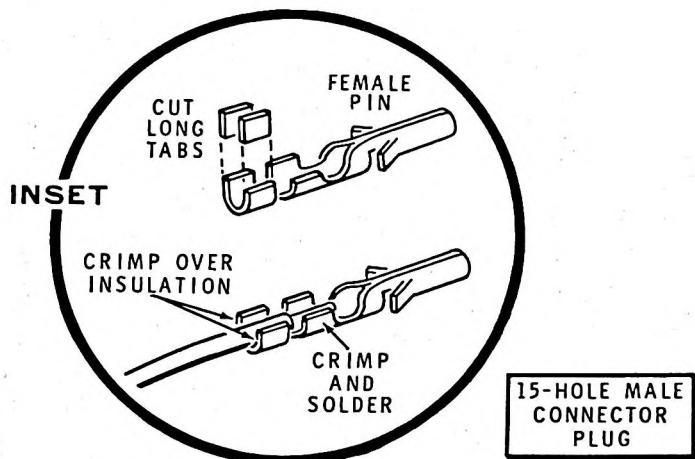
**Detail 2-2F**

- ( ) Refer to the inset drawing in Detail 2-2G and crimp and solder female pins on the ends of the 1" separated wires of the 5-1/2" 8-wire cable. Trim the long pin tabs as before.
- ( ) Similarly crimp and solder female pins on the ends of the 1" separated wires of the 5-1/2" brown and red 2-wire cable.
- ( ) Crimp and solder female pins on the free wire ends of the green, blue, violet, and gray 4-wire cable coming from the 24-pin female connector.

**NOTE:** In the following steps, you will insert female pins into the 15-pin male connector plug. As before, make sure to start all of the wires into their designated holes, and then double check to make sure they are right before you press them the rest of the way in.

Refer to Detail 2-2G and position the 15-pin male connector plug with the ridges as shown. Then insert the female pins on the end of the 5-1/2" 8-wire cable into the plug as follows:

- ( ) Brown wire at hole 1.
- ( ) Red wire at hole 2.
- ( ) Orange wire at hole 3.
- ( ) Yellow wire at hole 4.
- ( ) Green wire at hole 5.
- ( ) Blue wire at hole 6.
- ( ) Violet wire at hole 7.
- ( ) Gray wire at hole 8.

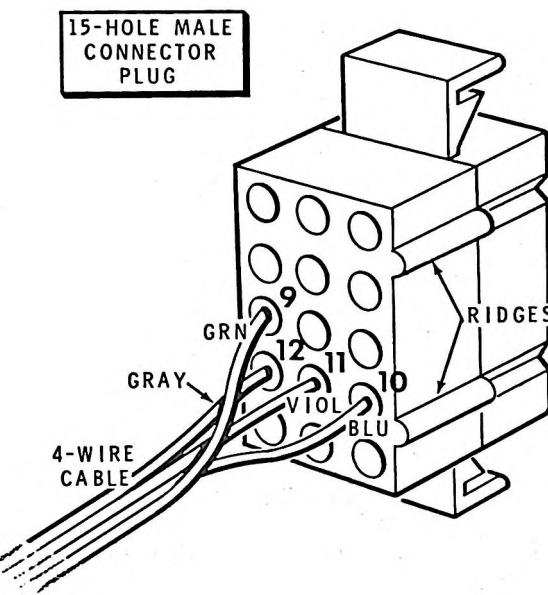
**Detail 2-2G**

Refer to Detail 2-2H and insert the female pins on the end of the 4-wire cable coming from the 24-hole female connector socket into the 15-hole male connector plug as follows:

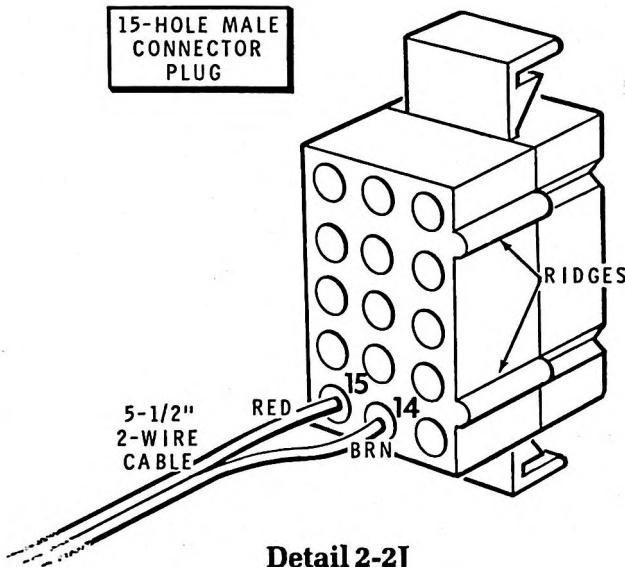
- Green wire at hole 9.
- Blue wire at hole 10.
- Violet wire at hole 11.
- Gray wire at hole 12.

Refer to Detail 2-2J and insert the female pins on the end of the 5-1/2" red and brown 2-wire cable into the 15-hole male connector plug as follows:

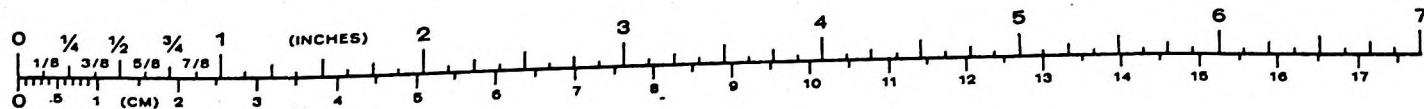
- Brown wire at hole 14.
- Red wire at hole 15.



**Detail 2-2H**



**Detail 2-2J**



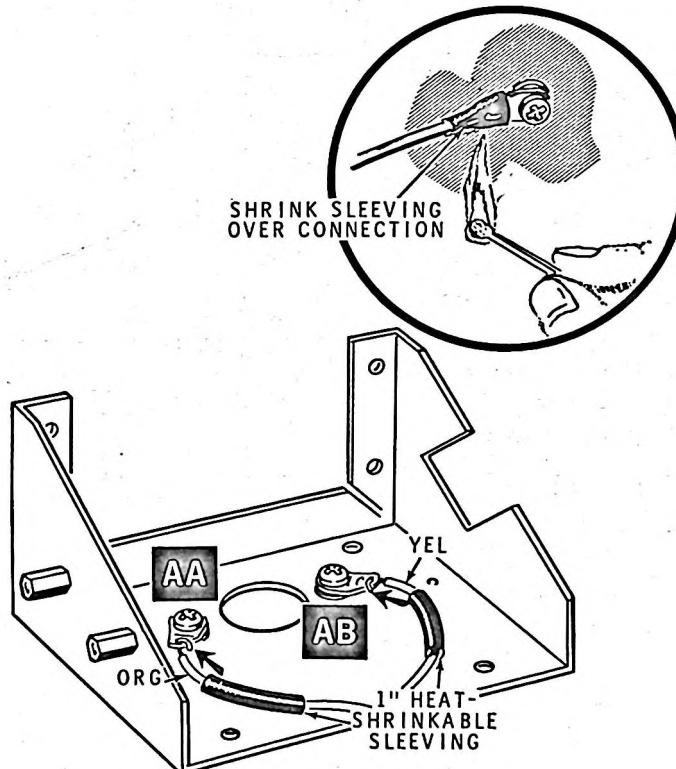
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Refer to Pictorial 2-3 (Illustration Booklet, Page 5) for the following steps.

- ( ) Position the arm mounting bracket as shown.
- ( ) Cut two 1" pieces of heat-shrinkable sleeving.
- ( ) Refer to Detail 2-3A and slide 1" pieces of heat-shrinkable sleeving over the orange and yellow wires at the 3-1/2" separated end of the 2-wire cable. Then solder the orange wire to solder lug AA and the yellow wire to solder lug AB.
- ( ) When the connections cool, slide the heat-shrinkable sleeving over solder lugs AA and AB. Use a lighter or a match and heat the sleeving so it shrinks into place around the connections. Do not use too much heat or you will crack the sleeving. NOTE: You will connect the free end of the 2-wire cable later.
- ( ) Mount the shoulder motor (#420-629) to the arm bracket with #10 lockwashers and 10-32 nuts. Do not pinch the yellow and orange wires under the motor hardware.

- ( ) Mount the actuator to the round bushing with a 4-40 × 3/16" black phillips head screw. Use the smaller of the two threaded holes. Position the actuator on the bushing as shown.
- ( ) Use the #8 allen wrench and start an 8-32 × 1/4" allen setscrew into the larger threaded hole in the round bushing. Then position the round bushing with the actuator on top of spacer AA and slide the bushing over the shoulder motor shaft as far as it will go. Tighten the setscrew with the #8 allen wrench.
- ( ) Mount the shoulder circuit board (foil side out) to actuator bracket hex spacers AC and AD with 4-40 × 1/4" black phillips head screws. Position the circuit board with the part number as shown.



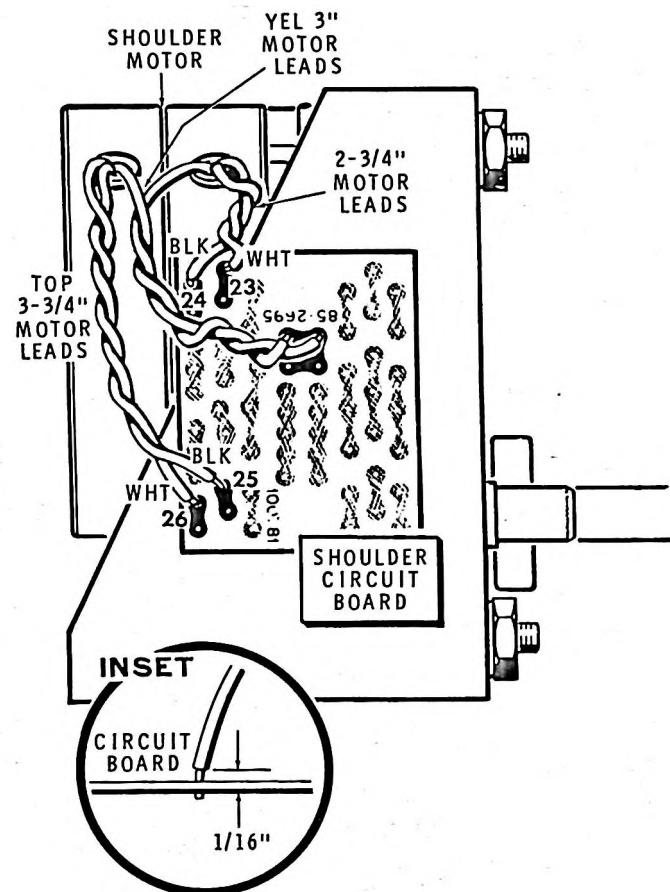
**Detail 2-3A**

Refer to Pictorial 2-4 for the following steps.

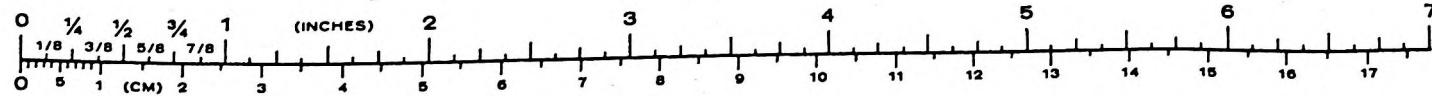
**NOTE:** When you cut the shoulder motor leads in the following steps, measure the leads from the point at which they leave the motor.

- ( ) Cut the yellow shoulder motor leads to 3" and prepare the ends to 1/8".
- ( ) Twist the yellow motor leads together and connect them to shoulder circuit board holes 21 and 22. Position the leads so the edge of the insulation is 1/16" above the foil (see the inset drawing), and solder the leads to the foil.

- ( ) Cut the top black and white shoulder motor leads to 3-3/4" and prepare the ends for 1/8".
- ( ) Twist the 3-3/4" motor leads together. Then connect the top white lead to shoulder circuit board hole 26 and the top black lead to hole 25. Solder the leads after you connect them.
- ( ) Cut the remaining black and white shoulder motor leads to 2-3/4" and prepare the ends for 1/8".
- ( ) Twist the 2-3/4" motor leads together and connect the black lead to shoulder circuit board hole 24 and the white lead to hole 23.



**PICTORIAL 2-4**



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Refer to Part A of Pictorial 2-5 (Illustration Booklet, Page 5) for the following steps.

Connect the 9" 8-wire cable coming from the 24-hole female connector socket to the shoulder circuit board as follows. Solder each wire to the circuit board after you connect it and be careful not to burn any adjacent wires when you solder to the circuit board foils.

- ( ) Brown wire at hole 7.
- ( ) Red wire at hole 8.
- ( ) Orange wire at hole 9.
- ( ) Yellow wire at hole 10.
- ( ) Gray wire at hole 34.
- ( ) Violet wire at hole 33.
- ( ) Blue wire at hole 32.
- ( ) Green wire at hole 31.

Refer to Part B of Pictorial 2-5 (Illustration Booklet, Page 5) for the following steps.

Connect the 9" brown, red, and orange 3-wire cable coming from the 24-hole female connector socket to the shoulder circuit board as follows. Solder each wire to the circuit board after you connect it and be careful not to burn any adjacent wires when you solder to the circuit board foils.

- ( ) Brown wire at hole 13.
- ( ) Red wire at hole 12.
- ( ) Orange wire at hole 15.

Refer to Part C of Pictorial 2-5 (Illustration Booklet, Page 5) for the following steps.

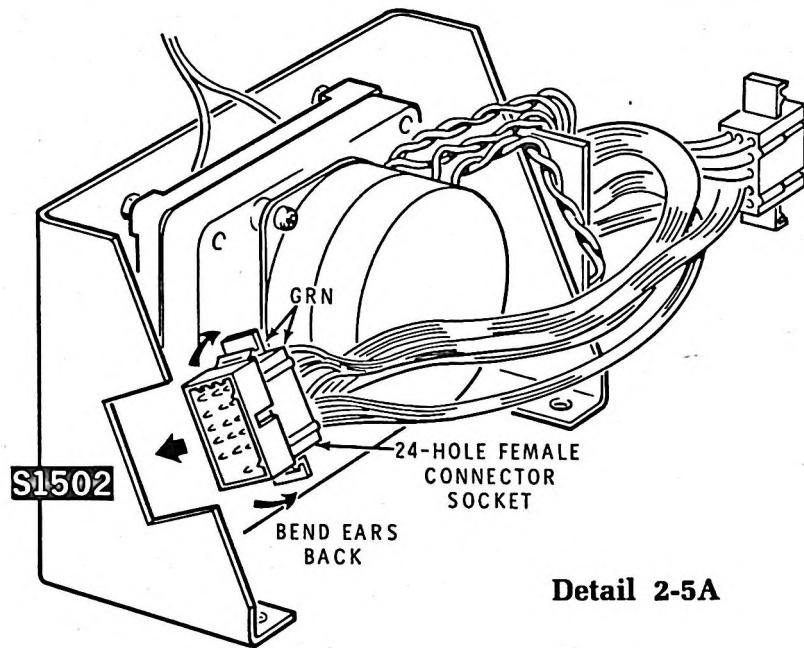
Connect the 5-1/2" 8-wire cable coming from the 15-hole male connector plug to the shoulder circuit board as follows. Solder each wire to the circuit board after you connect it and be careful not to burn any adjacent wires when you solder to the circuit board foils.

- ( ) Yellow wire at hole 2.
- ( ) Red wire at hole 4.
- ( ) Orange wire at hole 3.
- ( ) Brown wire at hole 5.
- ( ) Gray wire at hole 27.
- ( ) Violet wire at hole 28.
- ( ) Blue wire at hole 29.
- ( ) Green wire at hole 30.

Refer to Part D of Pictorial 2-5 (Illustration Booklet, Page 5) for the following steps.

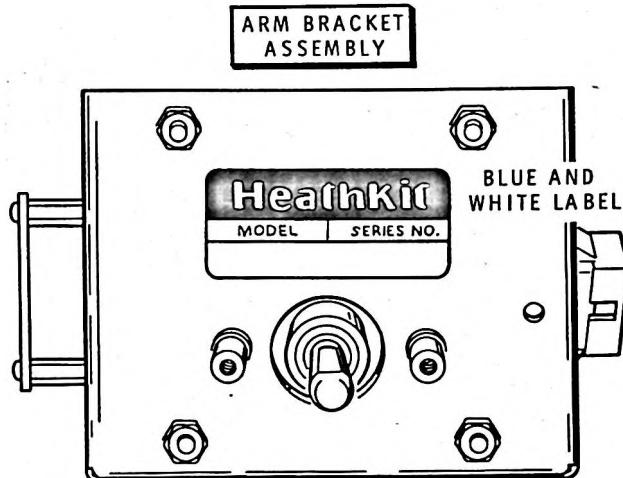
Connect the 5-1/2" brown and red 2-wire cable coming from the 15-hole male connector plug to the shoulder circuit board as follows. Solder each wire to the circuit board after you connect it and be careful not to burn any adjacent wires when you solder to the circuit board foils.

- ( ) Brown wire at hole 11.
- ( ) Red wire at hole 14.

**Detail 2-5A**

- ( ) Refer to Detail 2-5A and bend the ears back on the 24-hole female connector socket. Position the green socket wires as shown and slide the socket into the arm mounting bracket hole at S1502.
- ( ) Refer to Detail 2-5B, remove the backing paper from the blue and white label, and press the label onto the arm bracket assembly at the indicated location. Refer to the numbers on this label in any correspondence you may have with the Heath Company concerning this kit.

This completes the "Arm Bracket Assembly." Set it aside until it is called for later.

**Detail 2-5B**



## ARM ASSEMBLY

Refer to Pictorial 2-6 (Illustration Booklet, Page 6) and Detail 2-6A for the following steps.

- ( ) 1. Wrap pieces of tape around the bottom yellow and gray arm extend motor leads. Keep the tape approximately 1-1/2" from the lead ends. The tape will identify the leads when you connect them later on.

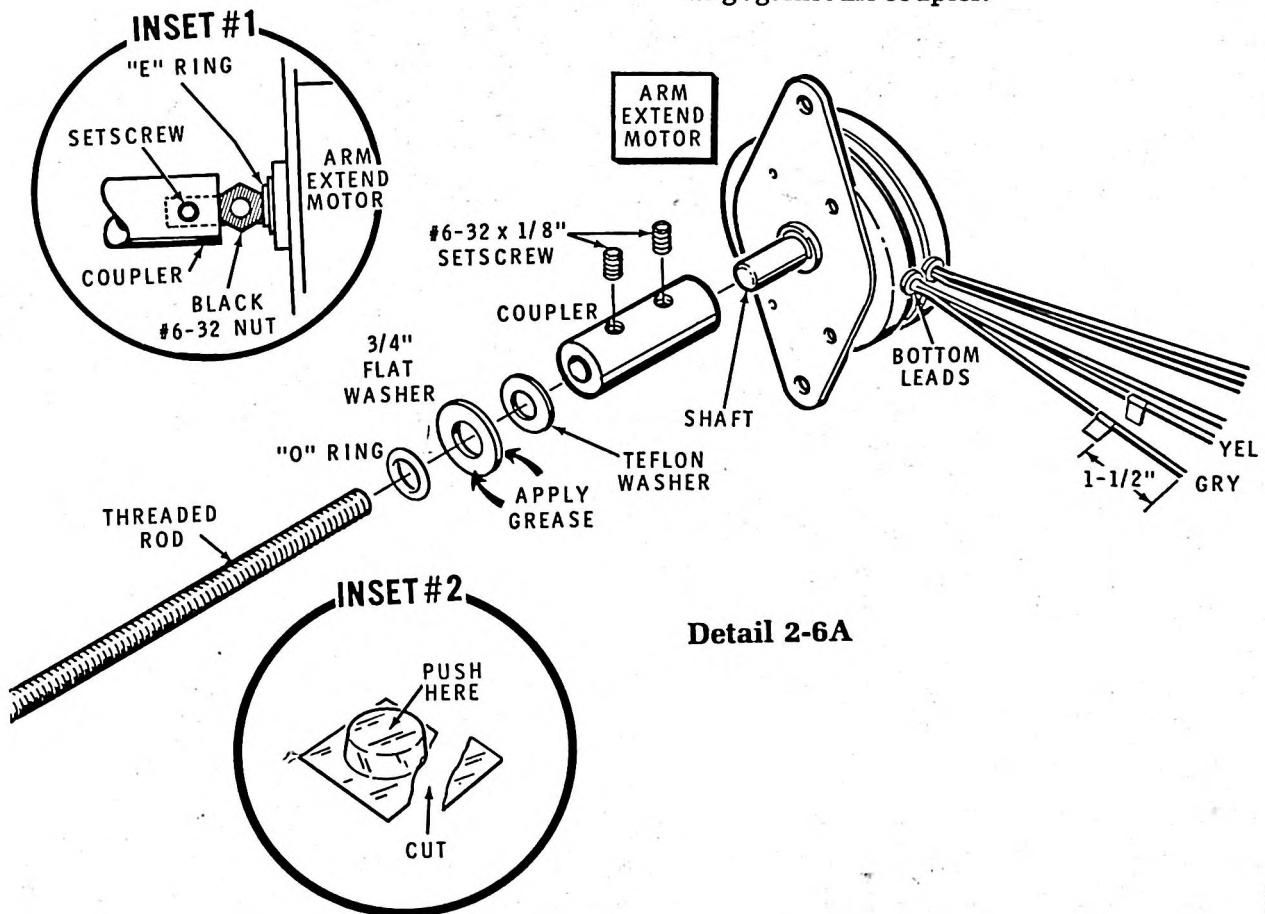
Mount the coupler to the arm extend motor as follows:

- ( ) 1. Start two 6-32 × 1/8" setscrews into the coupler holes. Use the #6 allen wrench.
- ( ) 2. Slide the coupler over the arm extend motor shaft. Refer to inset drawing #1 of the Detail and position a 6-32 black nut between the motor E-ring and the end of the coupler. Then tighten the inside setscrew with the #6 allen wrench. Remove the black nut and set it aside.

- ( ) 3. Slide the rubber "O" ring over one end of the threaded rod for about 1".

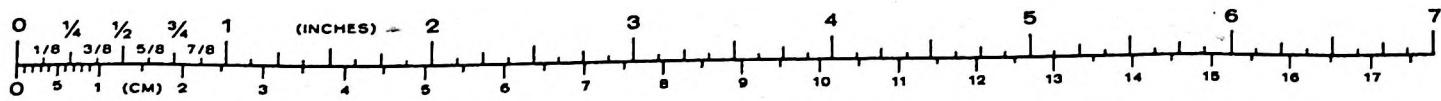
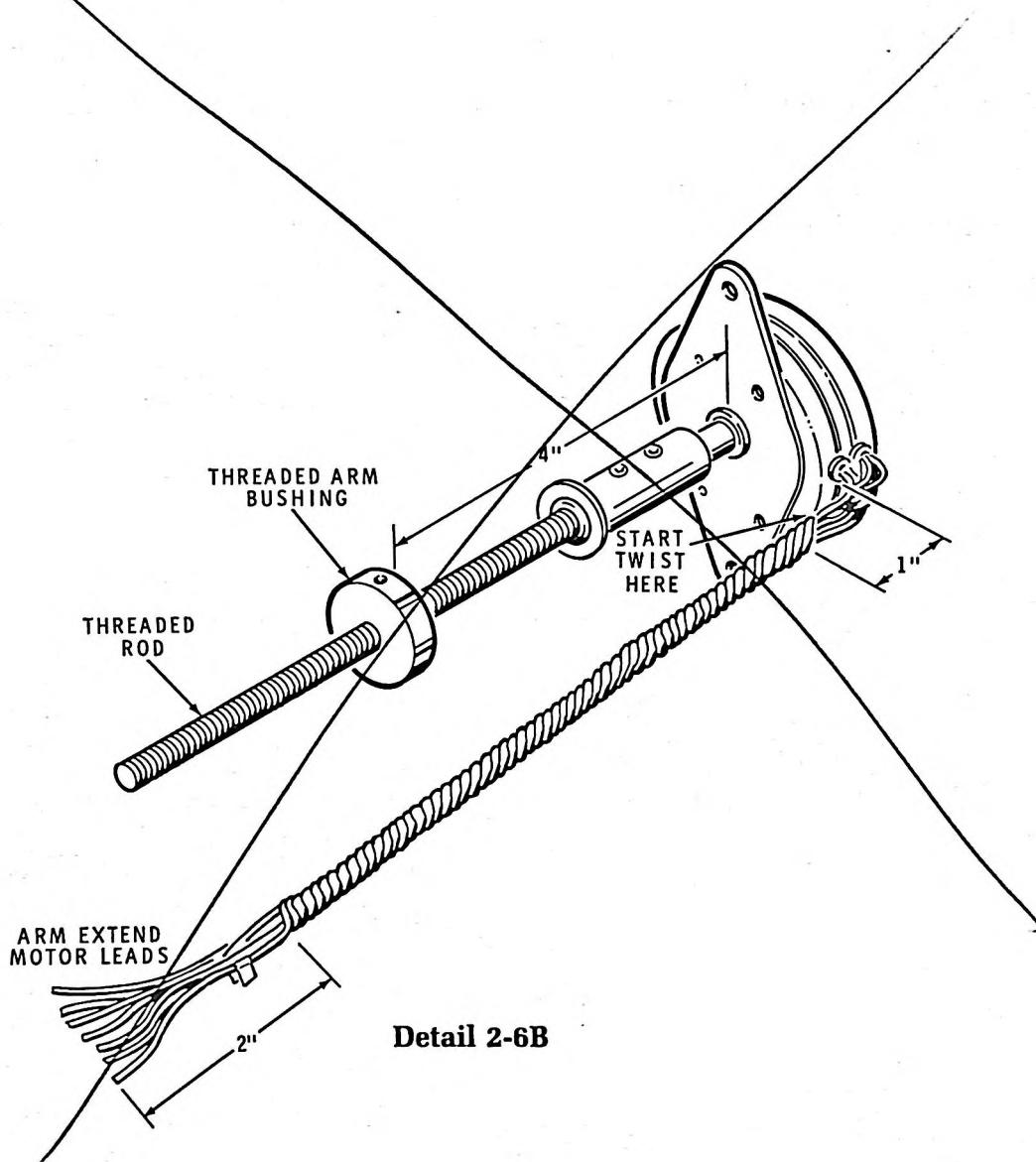
NOTE: The grease you will use in the following steps is not caustic. However, make sure you do not get it in your eyes, ears, nose, mouth, or on your clothing. Always wash your hands after you use the grease. Keep this and all chemicals out of the reach of children.

- ( ) 4. Refer to inset drawing #2 of the Detail and open a container of grease. Then apply a liberal amount of the grease to both sides of a 3/4" flat washer. Slide the flat washer and the teflon washer over the end of the threaded rod against the "O" ring. Set the grease aside.
- ( ) 5. Insert the end of the threaded rod with the flat washer and "O" ring into the end of the coupler until it is against the motor shaft. Then tighten the remaining coupler setscrew with the #6 allen wrench.
- ( ) 6. Slide the 3/4" flat washer and the rubber "O" ring against the coupler.



Detail 2-6A

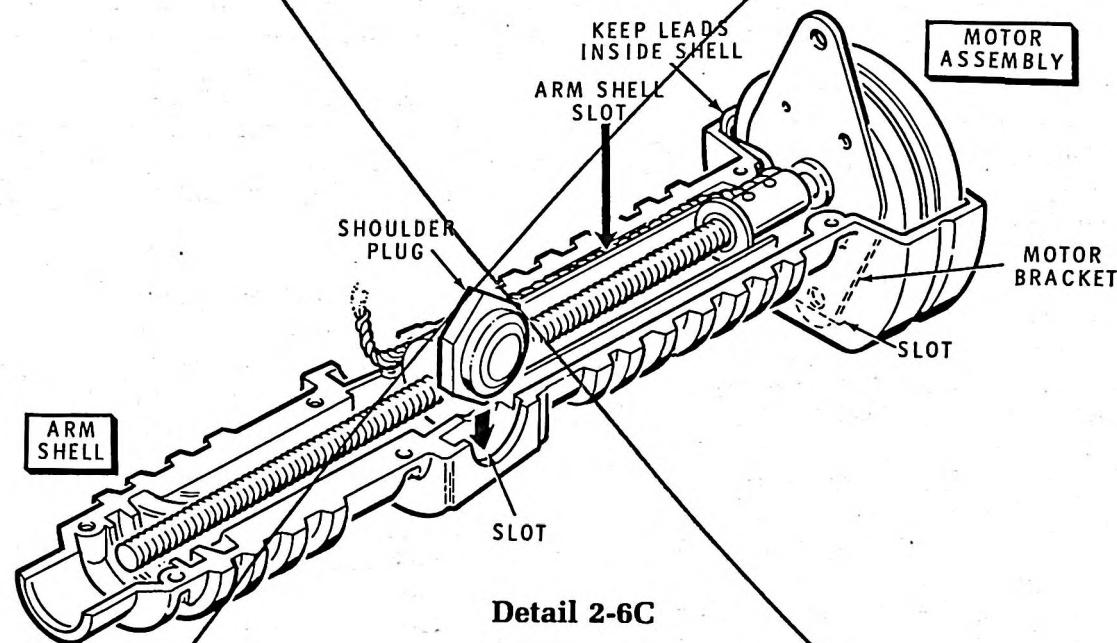
- ( ) Refer to Detail 2-6B and twist the threaded arm bushing onto the threaded rod. Position it approximately 4" from the end of the arm extend motor.
- ( ) Refer to Detail 2-6B and twist the arm extend motor leads tightly together, 1" past the motor case and 2" from the lead ends.



**NOTE:** In the following step, you will install the motor assembly into one of the two arm shells. One of the arm shells has a straight track molded inside and the other has a curved track. During operation of the Arm, the straight track arm shell will allow the wrist to remain in a fixed position when the arm is fully extended. The curved track arm shell will cause the wrist to pivot 90° during the last 2 inches of travel. Determine which of these features you would like your Robot Arm to perform; then set that arm shell aside and use the other arm shell in the following step.

Refer to Detail 2-6C for the following steps.

- ( ) Position one of the arm shells as shown. Install the motor assembly into the arm shell with the leads as shown. Make sure the motor bracket fits into its slot in the shell.
- ( ) Insert the twisted motor leads into the arm shell slot. Route the leads, as they leave the motor, around the inside of the shell so they will not be pinched when you install the other arm shell.
- ( ) Press the shoulder plug into its arm shell slot.



- ( ) Spread some of the grease over the length of the threaded rod. It is not necessary to cover the entire rod. The arm bushing will distribute it into the grooves after the arm is in operation.

Refer to Detail 2-6D (Illustration Booklet, Page 7) for the following steps.

- ( ) Slide a 7/8" brass bushing over the threaded hole end of the tubing and keep it near this end. You can position the bushing either way.
- ( ) Position the threaded hole in the threaded arm bushing facing up.
- ( ) Slide the threaded hole end of the tubing with the 7/8" bushing over the threaded rod and align the large mounting hole in the tubing with the threaded arm bushing hole.
- ( ) Install the 4-40 × 3/8" shoulder spacer and a 1/4" bushing through the large mounting hole in the tubing into the tapped hole in the threaded arm bushing. Be careful not to cross-thread the screw.
- ( ) Rotate the tubing so that one of the two threaded holes in the end faces up. Then slide the 7/8" brass bushing over the threaded tubing hole and install a 1-72 × 1/8" screw into the hole.

- ( ) Lift the tubing slightly so the 4-40 × 3/8" shoulder spacer and 1/4" bushing clears the arm shell. Rotate the tubing so that the other threaded hole faces up and install the remaining 1-72 × 1/8" screw into the hole.

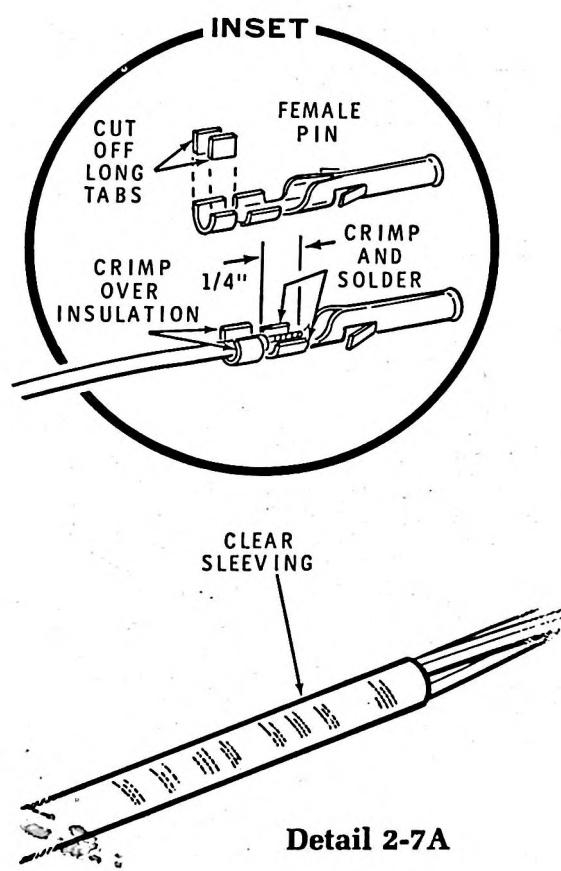
- ( ) Rotate the tubing so the 4-40 × 3/8" shoulder spacer and 1/4" bushing faces up.

Refer to Detail 2-6E (Illustration Booklet, Page 8) for the following steps.

- ( ) Position the round brass shoulder bushing as shown. Slide it over the end of the tubing and press the bushing shoulder into its arm shell slot.
- ( ) Position the hex shoulder bushing as shown and insert the arm extend motor leads through the bushing holes.
- ( ) Mount 8-32 × 1/4" allen setscrews into the threaded holes of the hex shoulder bushing. Turn the setscrews until they are flush with the outside edge of the bushing.
- ( ) Position the hex shoulder bushing with the small threaded mounting hole as shown. Press the hex bushing shoulder into its arm slot.
- ( ) Install a cable tie around the hex shoulder bushing and the arm extend motor leads just below the bushing hole as shown.
- ( ) Apply a liberal amount of grease to the center track of the other arm shell. Apply the grease with a stick to the bottom and sides of the track. Set the grease aside.

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- ( ) Check to make sure the motor leads are positioned inside the arm shell slot and down inside the shell near the motor. Then carefully mount the two arm shell halves together with 6-32 x 3/8" black phillips head screws, 6-32 black nuts, and a #8 long solder lug. Mount the solder lug between the arm shells. Make sure the motor flange and shoulder bushings seat into their slots properly and that the 3/8" shoulder screw and 1/4" bushing fits into its straight or curved track in the upper shell.

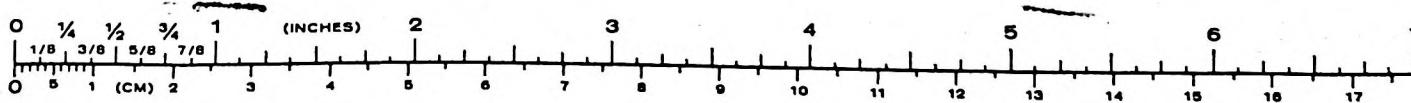


Refer to Pictorial 2-7 (Illustration Booklet, Page 8) for the following steps.

- ( ) Cut an 8" length of clear sleeving.
- ( ) Refer to Detail 2-7A and slide the 8" length of sleeving over the extend motor leads. Keep at least 1" of the motor leads extending past the end of the sleeving.
- ( ) Cut the bare wire ends of each lead to 1/4".
- ( ) Refer to the inset drawing of Detail 2-7A and crimp and solder female pins on the arm extend motor leads. Trim the pin tabs as shown.

Position the 24-hole male connector plug with the notches as shown. Then insert the female pins on the ends of the arm extend motor leads into the connector plug holes as follows. Make sure you install the colored leads at their designated hole locations.

- ( ) Taped yellow lead at hole 6.
- ( ) Taped gray lead at hole 2.
- ( ) Remaining yellow lead at hole 10.
- ( ) Remaining gray lead at hole 14.
- ( ) Either black lead at hole 21.
- ( ) Other black lead at hole 22.
- ( ) Either red lead at hole 23.
- ( ) Other red lead at hole 24.



Refer to Pictorial 2-8 (Illustration Booklet, Page 9) for the following steps.

- ( ) Locate the 10-wire spiral cable and prepare all the wires at both ends for 1/8".
- ( ) Remove the outer insulation of the shortest straight end of the 10-wire spiral cable so the individual wires extend 1-7/8" from the end as shown. Be careful not to cut into the inner wire insulation when you remove the outer insulation.
- ( ) Crimp and solder female pins on the wire ends at the longest straight section of the 10-wire spiral cable. Trim the pin tabs as before.
- ( ) Refer to Detail 2-8A and position the 24-hole male connector plug with the notches as shown. Then insert the female pins on the ends of the 10-wire spiral cable wires into the connector plug holes as follows:

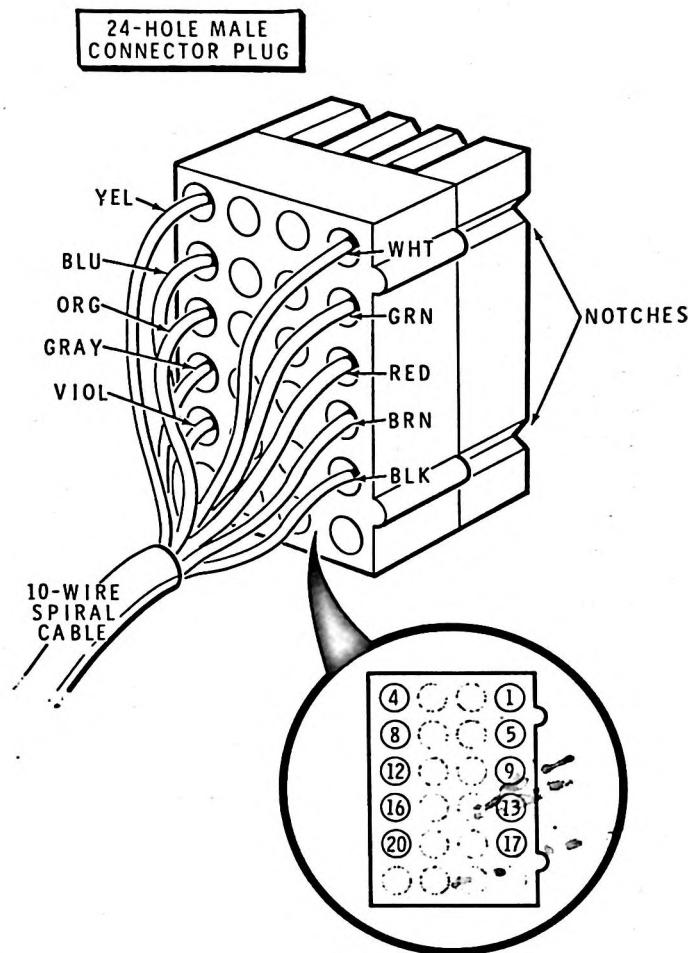
  - ( ) White wire at hole 1.
  - ( ) Yellow wire at hole 4.
  - ( ) Green wire at hole 5.
  - ( ) Blue wire at hole 8.
  - ( ) Red wire at hole 9.
  - ( ) Orange wire at hole 12.
  - ( ) Brown wire at hole 13.
  - ( ) Gray wire at hole 16.
  - ( ) Black wire at hole 17.
  - ( ) Violet wire at hole 20.

- ( ) Install a cable tie around the arm cables and the hex shoulder bushing. Leave approximately 10" of cable between the cable tie and the end of the connector plug as shown.

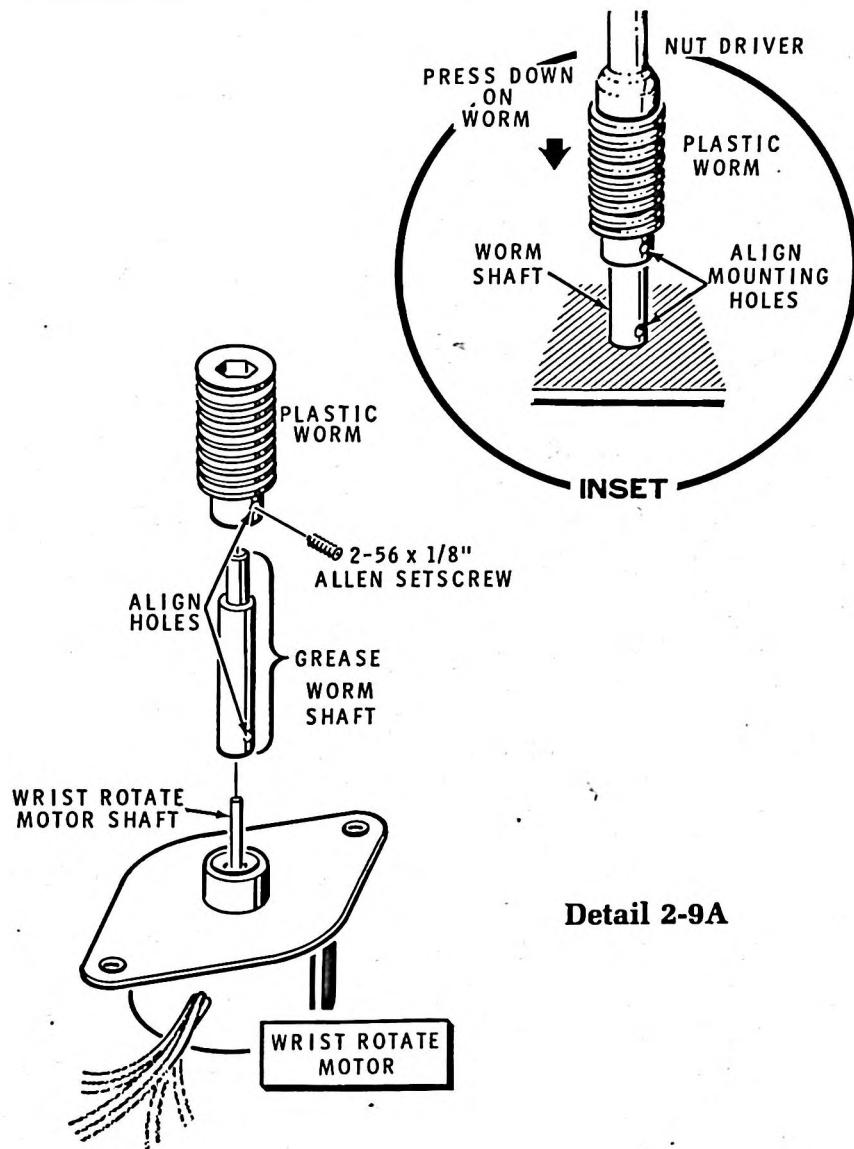
( ) Push the 24-hole male connector plug through the bellows and over the hex shoulder bushing and cable tie.

( ) Coil the 10-wire spiral cable around the front of the arm and wrap the #8 long solder lug around the cable as shown.

This completes the "Arm Assembly." Set the arm aside until it is called for in a step.



**Detail 2-8A**



Detail 2-9A

**GRIPPER ASSEMBLY**

Refer to Pictorial 2-9 (Illustration Booklet, Page 10) for the following steps.

( ) Position the motor housing top as shown.

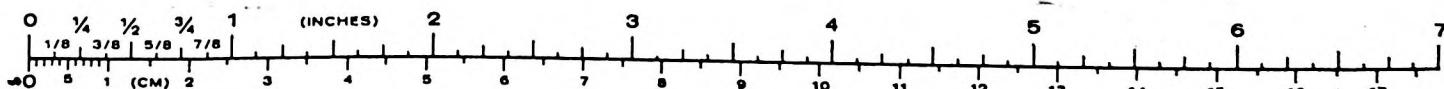
Refer to Detail 2-9A for the following four numbered steps.

( ) 1. Spread a thin layer of the grease over the worm shaft. Then set the grease aside.

( ) 2. Start the worm shaft into the plastic worm so the mounting holes are directly in line.

Then place the end of the worm shaft against a hard, flat surface, and press the worm shaft into the worm with the  $3/16"$  nut driver until the mounting holes align. See the inset drawing.

- ( ) 3. If necessary, use the #2 allen wrench to start the  $2-56 \times 1/8"$  allen setscrew into the worm shaft. Be careful not to cross thread this setscrew with the shaft threads.
- ( ) 4. Mount the worm assembly onto the wrist rotate motor shaft as far as it will go with the setscrew toward the motor. Tighten the setscrew with the #2 allen wrench.



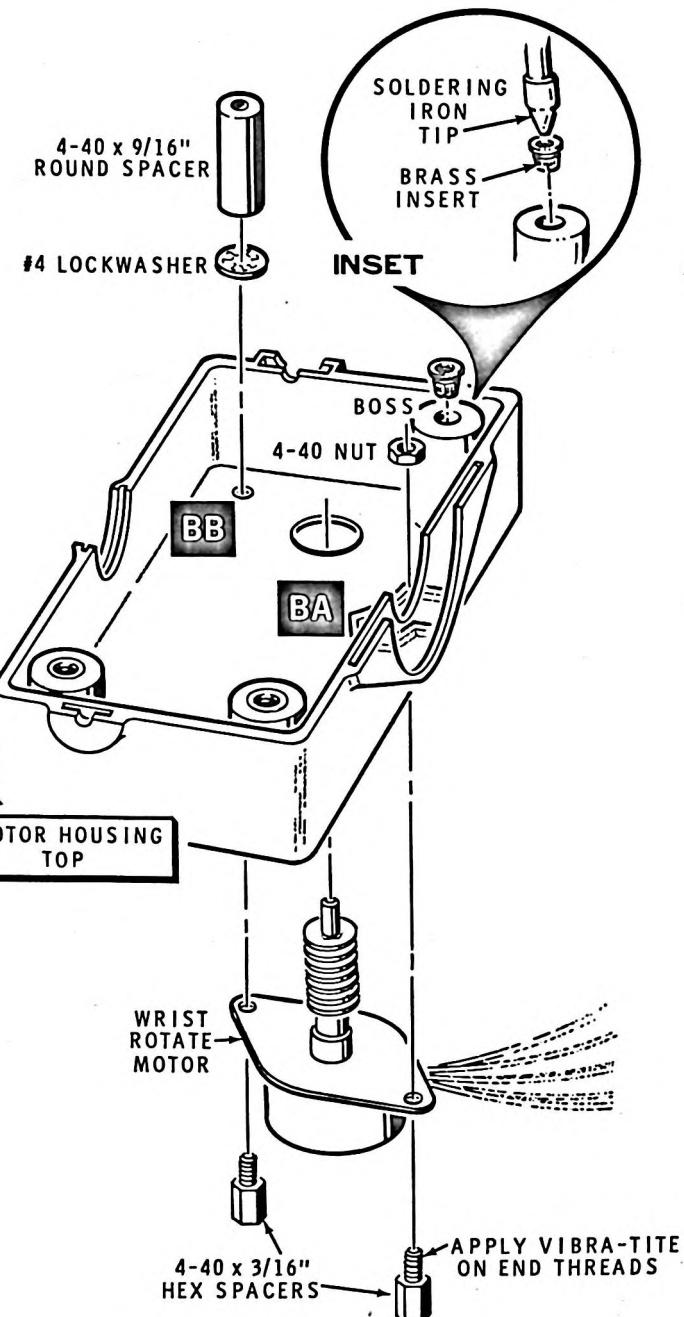
- ( ) Refer to Detail 2-9B and install 4-40 brass inserts into the three motor housing bosses. Press the inserts into the holes as far as possible. If the top edge of the insert is not even with the top edge of the housing top, use the tip of your soldering iron and heat the insert slightly while you press it into place. See the inset drawing in Detail 2-9B.

**NOTE:** In the following step you will use the container of Vibra-Tite. Use the following procedure whenever you use the Vibra-Tite:

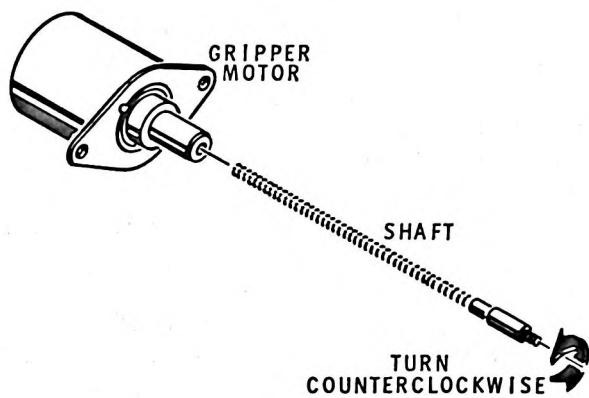
1. Refer to the inset drawing and use a pair of scissors to clip off the tip of the nipple of the container. Be careful not to allow the contents to squirt out onto your clothing, hands, or work surface.
2. Spread the Vibra-Tite completely around threads of the screw you are going to install.
3. After the screw is installed, allow the Vibra-Tite to dry for approximately 30 minutes.

**CAUTION:** Vibra-Tite contains Trichloroethane. If swallowed, induce vomiting and call a physician. Avoid contact with your skin and eyes and use adequate ventilation. In case of eye contact, flush the eye thoroughly with water.

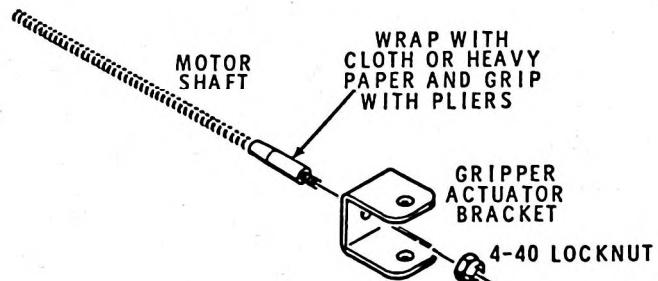
- ( ) Apply a small amount of Vibra-Tite over the end threads of one of the  $4-40 \times 3/16"$  hex spacers. Then set the Vibra-Tite aside.
- ( ) Refer to Detail 2-9B and loosely mount the wrist rotate motor to the motor housing top with the  $4-40 \times 3/16"$  hex spacer with the Vibra-Tite and a  $4-40 \times 1/4"$  nut at BA. Mount a  $4-40 \times 3/16"$  hex spacer, a #4 lockwasher and a  $4-40 \times 9/16"$  round spacer at BB. Position the motor with the leads as shown. Make the hardware only finger tight at this time.



**Detail 2-9B**

**Detail 2-9C**

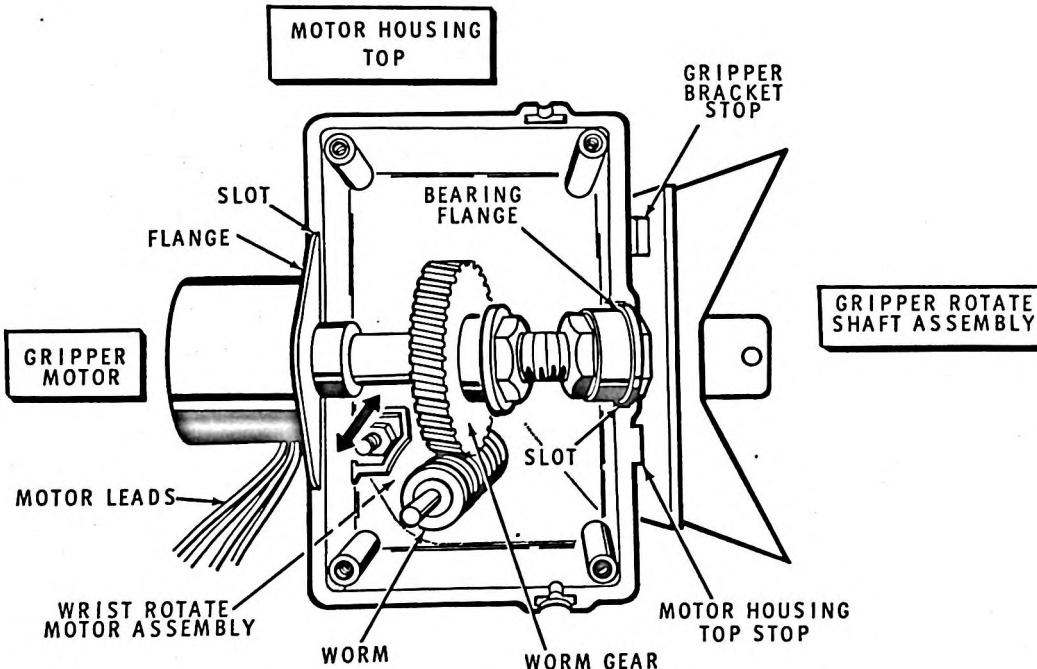
- ( ) Refer to Detail 2-9C and remove the shaft from the gripper motor by twisting it in a counterclockwise direction.
- ( ) Refer to Detail 2-9D and mount the gripper actuator bracket on the finely threaded end of the motor shaft with a 4-40 locknut. To tighten the locknut, wrap a cloth or a piece of heavy paper around the smooth part of the shaft just behind the fine threads and grip it with a pair of pliers. Then turn the locknut onto the shaft until it is just tight against the bracket.
- ( ) Set the gripper motor shaft assembly aside temporarily.

**Detail 2-9D**

Refer to Detail 2-9E (Illustration Booklet, Page 10) for the following four numbered steps.

- ( ) 1. Insert the hex threaded end of the gripper rotate shaft into the plastic gripper bracket so the hex end is seated in the bracket indent. Then mount the shaft to the bracket with a 9/16" flat washer and a 5/16" nut. Do not overtighten the nut.
- ( ) 2. Slide the worm gear bearing over the gripper rotate shaft with the flanged side against the hex end of the shaft. Secure the bearing with a 5/16" nut. Do not overtighten this nut or the bearing will bind. Rotate the bearing to make sure it rotates freely and smoothly.
- ( ) 3. Spread a small amount of Vibra-Tite over the threads of a 5/16" nut. Then install the nut onto the gripper rotate shaft so the edge of the nut is even with the first thread on the gripper rotate shaft as shown in inset drawing #1. Set the Vibra-Tite aside.
- ( ) 4. Install a control lockwasher, a plastic flat washer, the worm gear, and another plastic flat washer onto the gripper rotate shaft. Make sure you position the worm gear as shown. Push these onto the shaft as far as they will go, and then install the e-ring into the slot of the shaft.

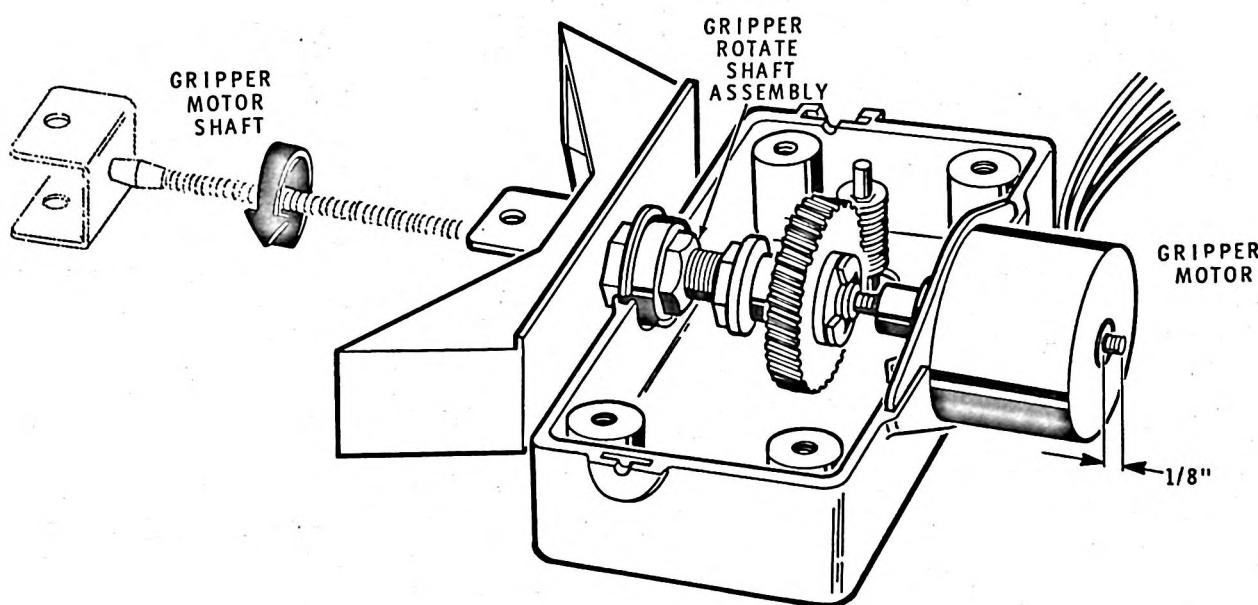
- ( ) 5. Spin the worm gear several times. It should spin freely. Now, as you spin the worm gear, turn the 5/16" nut with the Vibra-Tite until the gear no longer spins freely. Once you reach this point, use a pair of pliers and turn the nut an additional 1/6 turn (from point-to-point or flat-to-flat as shown in inset drawing #2).
- ( ) 6. Allow the assembly to sit for approximately 30 minutes to allow the Vibra-Tite to dry thoroughly.
- ( ) Refer to Detail 2-9F and position the gripper motor with the leads as shown. Then insert the motor flange into the slots in the motor housing top.
- ( ) Refer to Detail 2-9F and position the gripper rotate shaft assembly as shown. Insert the worm gear bearing flange into the slot in the motor housing top. You can position the gripper bracket stop on either side of the motor housing top stop. NOTE: Slide the wrist rotate motor assembly back if the worm and worm gears interfere.

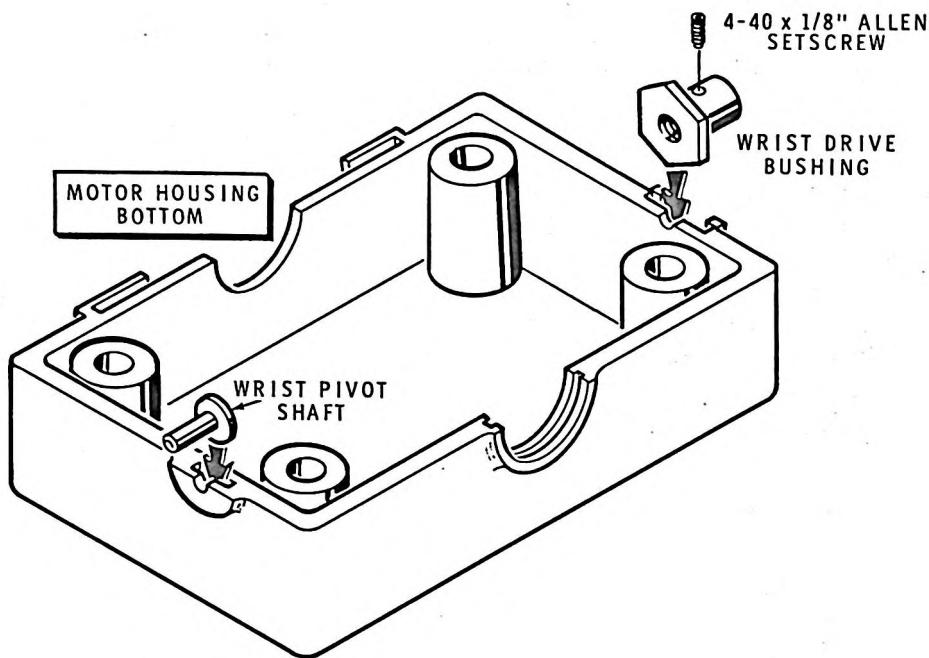


**Detail 2-9F**

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- ( ) Refer to Detail 2-9G and insert the free end of the gripper motor shaft through the gripper rotate shaft assembly. Then thread the motor shaft through the gripper motor in a clockwise direction until the end of the shaft is approximately  $1/8"$  through the end of the motor.
- ( ) Slide the wrist rotate motor forward so the worm and the worm gears mesh; then tighten the mounting spacers with the  $3/16"$  nutdriver you were supplied with. Rotate the worm on the motor shaft to make sure it rotates freely and smoothly. If it does not, loosen the wrist rotate hardware and slide the motor back slightly until the gears operate properly.
- ( ) Spread a small amount of grease over the threads of the worm. Discard the remaining grease.
- ( ) Set the motor housing top assembly aside temporarily.

**Detail 2-9G**

**PICTORIAL 2-10**

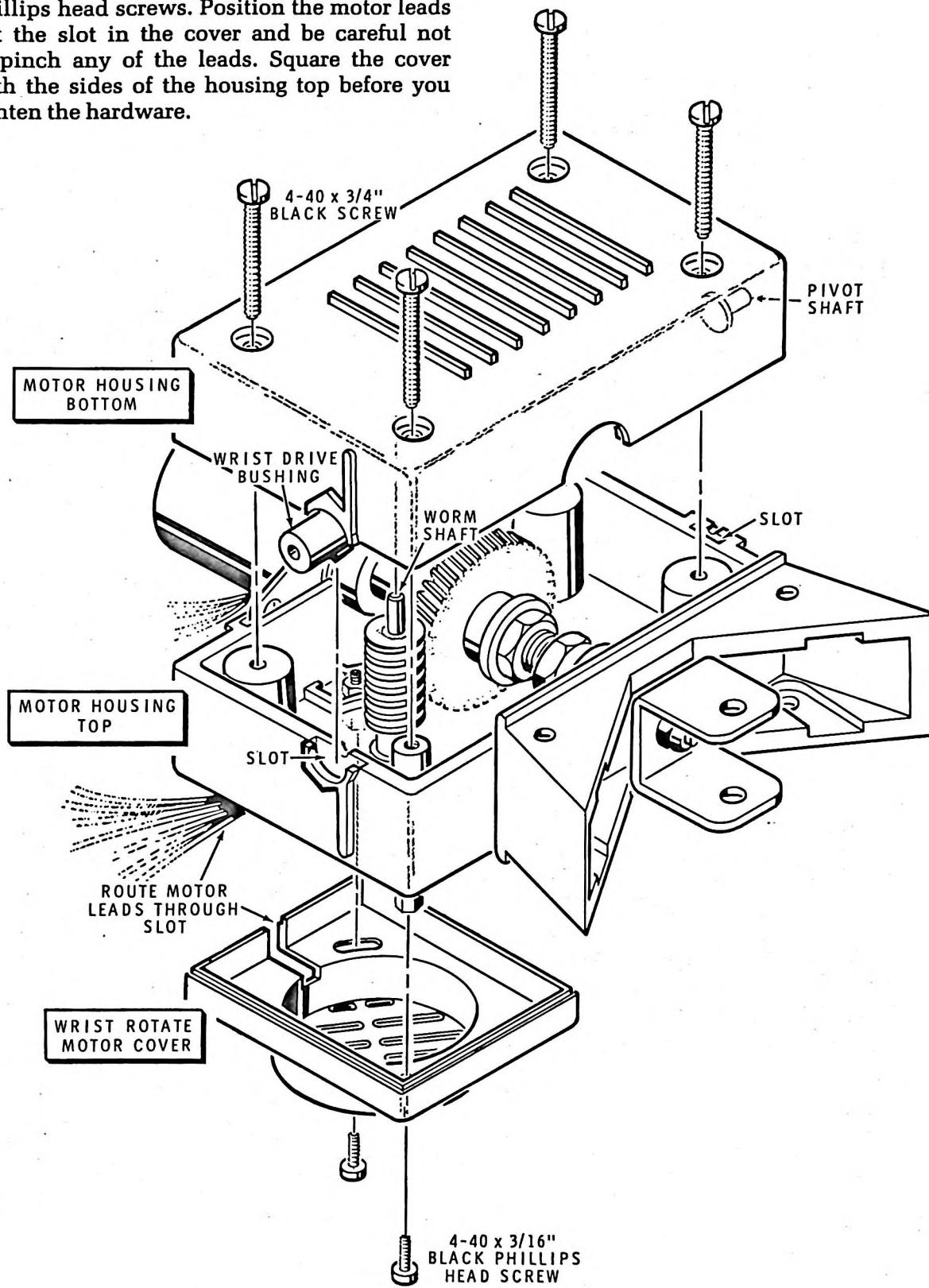
Refer to Pictorial 2-10 for the following steps.

- ( ) Position the motor housing bottom as shown.
- ( ) Press the wrist pivot shaft into its slot in the motor housing bottom.
- ( ) Use the medium allen wrench to start a 4-40 x 1/8" allen setscrew into the wrist drive bushing. Then press the bushing into its slot in the motor housing bottom with the setscrew positioned as shown.

Refer to Pictorial 2-11 for the following steps.

- ( ) Mount the motor housing bottom assembly onto the motor housing top with 4-40 x 3/4" black screws. Make sure the wrist pivot shaft and the wrist drive bushing go into their slots in the housing top.

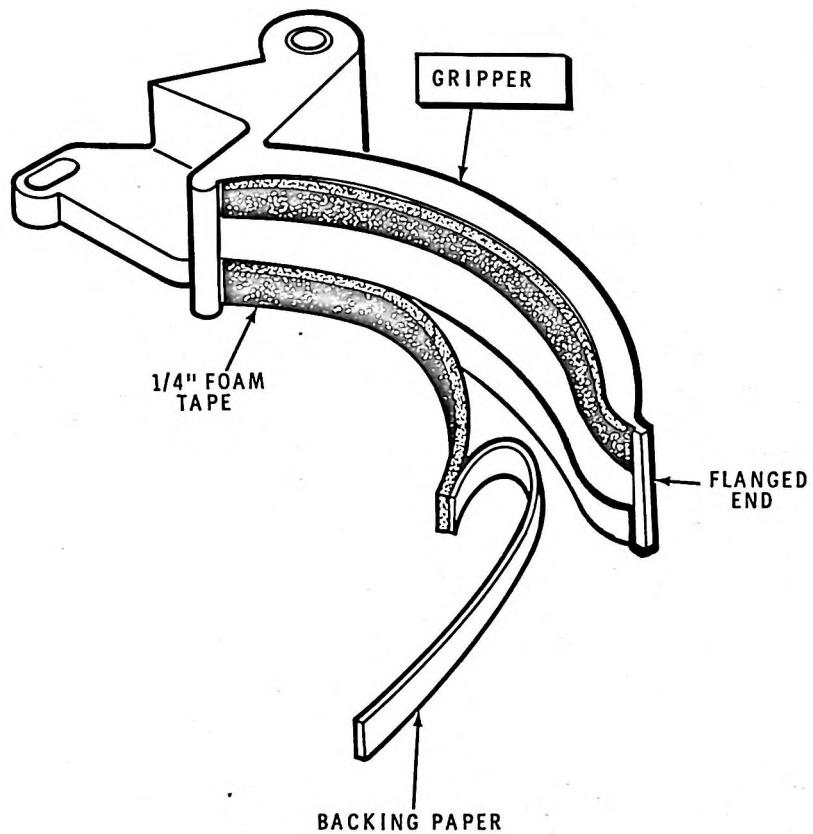
- ( ) Mount the wrist rotate motor cover to the motor housing top with 4-40 x 3/16" black phillips head screws. Position the motor leads out the slot in the cover and be careful not to pinch any of the leads. Square the cover with the sides of the housing top before you tighten the hardware.



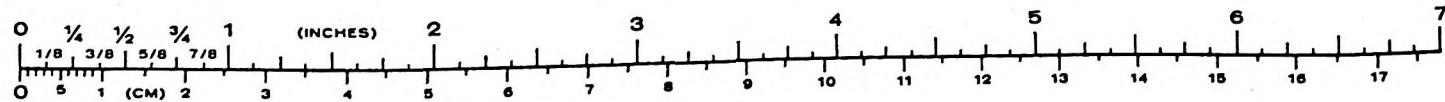
PICTORIAL 2-11

Refer to Pictorial 2-12 (Illustration Booklet, Page 11) for the following steps.

- ( ) Cut four 2-5/8" pieces of 1/4" foam tape.
- ( ) Refer to Detail 2-12A, remove the backing paper from one 2-5/8" piece of 1/4" foam tape, and press the tape along one of the sides of a gripper as shown. Keep the tape even with the flanged ends of the gripper.
- ( ) Similarly mount the remaining 2-5/8" pieces of 1/4" foam tape on the grippers.



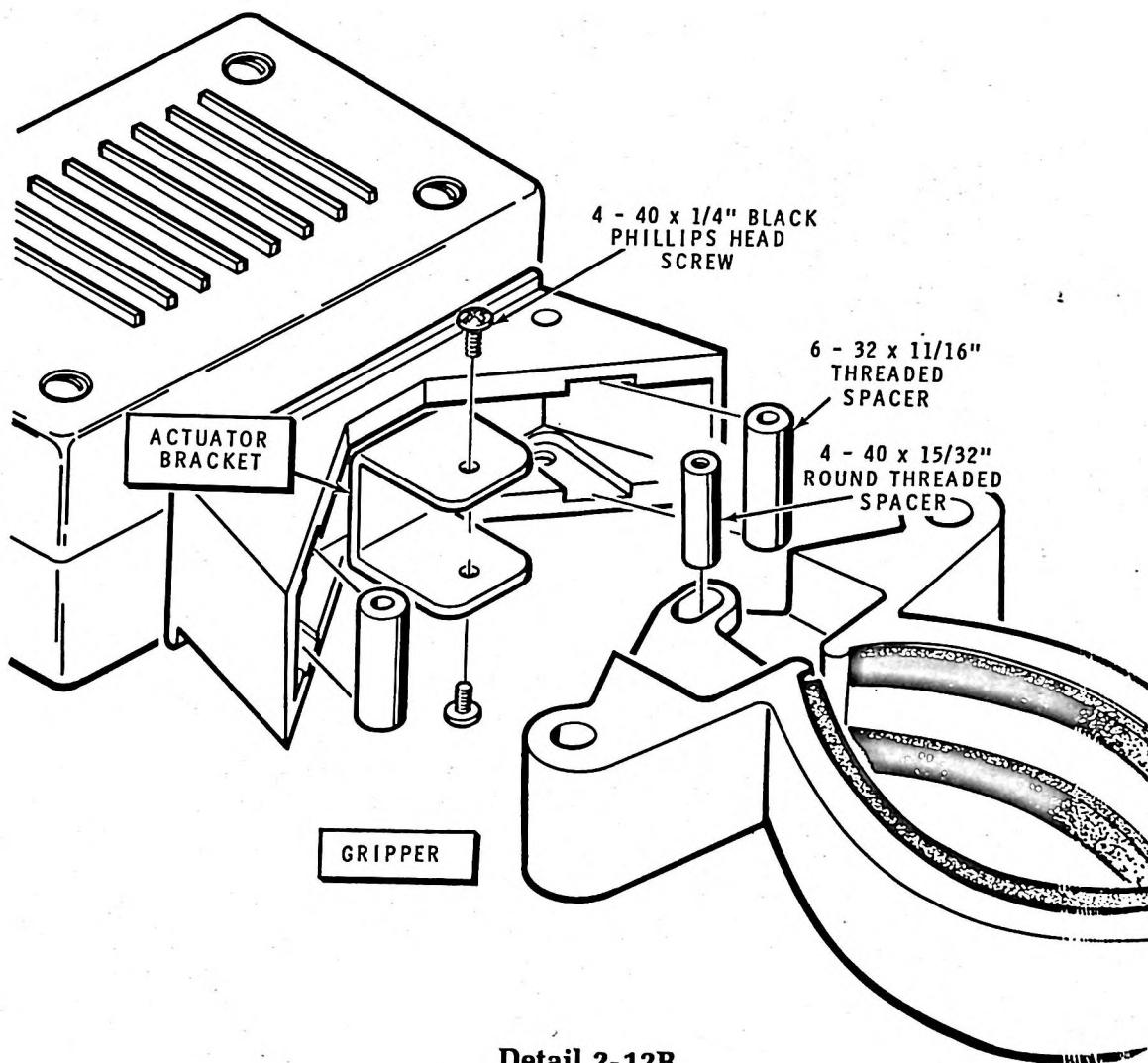
**Detail 2-12A**



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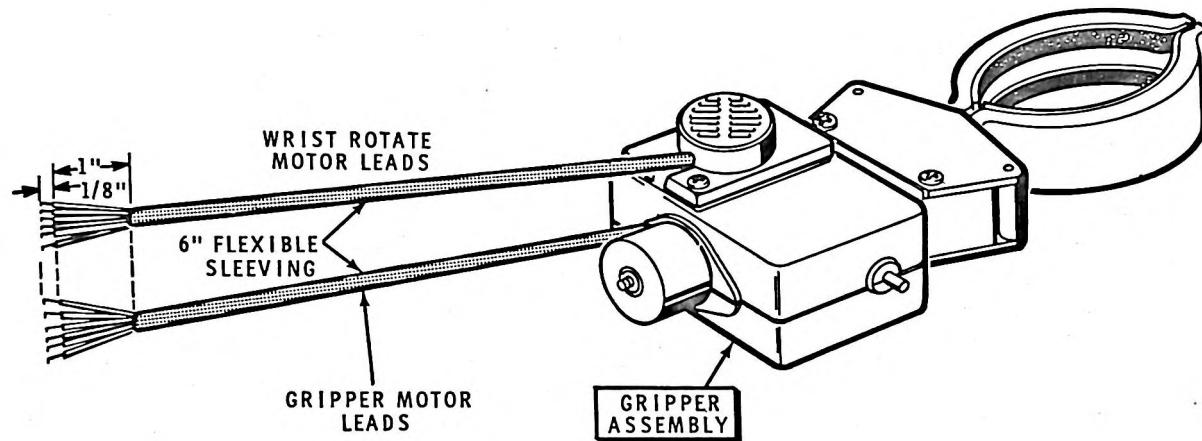
- ( ) Refer to Detail 2-12B and insert two  $6-32 \times 11/16"$  threaded spacers into the gripper bracket as shown. Make sure the mounting holes on both ends of the spacers align with the bracket mounting holes.
- ( ) Refer to Detail 2-12B, align the center gripper holes, and insert a  $4-40 \times 15/32"$  round threaded spacer in the holes. Then mount the grippers to the actuator bracket with two  $4-40 \times 1/4"$  black phillips head screws.
- ( ) Mount one of the cover plates to either side of the gripper bracket with  $6-32 \times 3/8"$  black philips head screws.
- ( ) Turn the gripper assembly over and insert gripper pivot shafts into the gripper holes. Seat the pins in the pivot shafts into the cover plate holes.
- ( ) Seat the pivot shaft pins into the remaining cover plate holes and mount the cover plate to the gripper bracket spacers with  $6-32 \times 3/8"$  black phillips head screws. Make sure the pivot shaft pins are in their cover plate mounting holes on both sides before you tighten the last two screws.



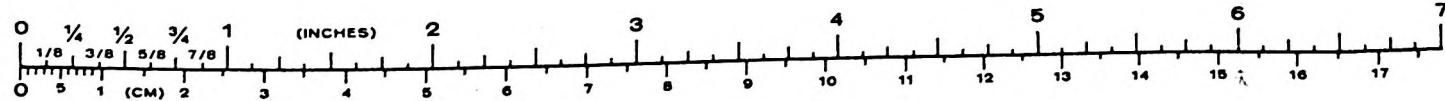
**Detail 2-12B**

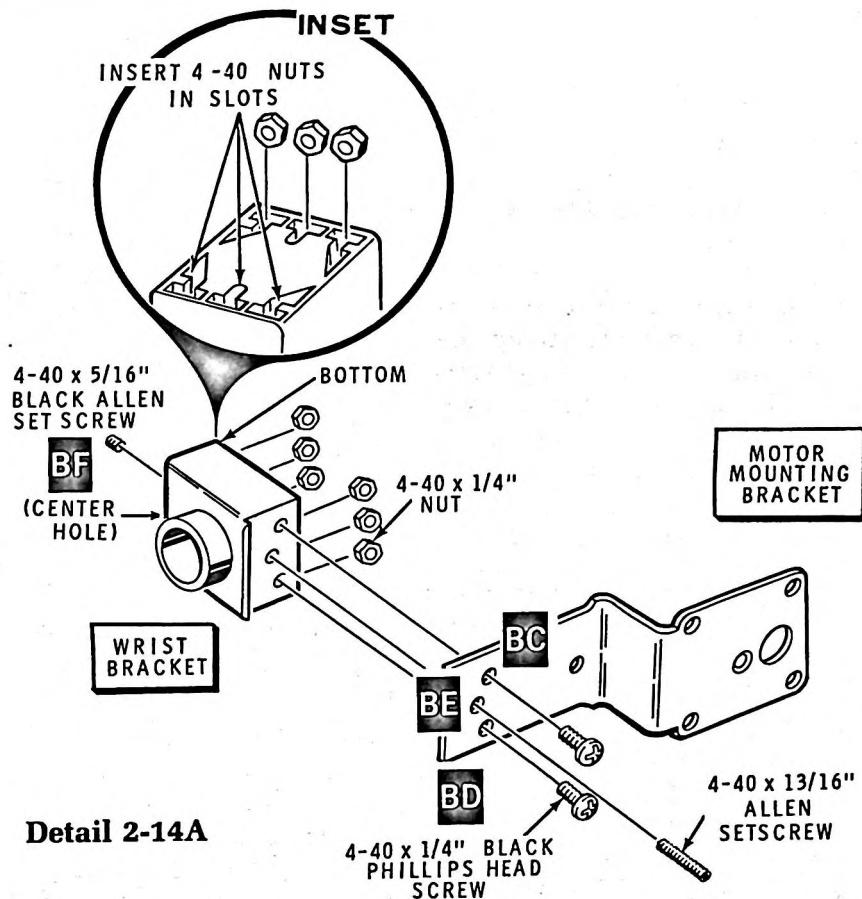
Refer to Pictorial 2-13 for the following steps.

- ( ) Cut the motor leads to 7".
- ( ) Prepare the wrist rotate motor lead ends to 1/8".
- ( ) Cut two 6" lengths of flexible sleeving.
- ( ) Slide one of the 6" lengths of flexible sleeving over the 7" wrist rotate motor leads. Slide the sleeving towards the motor.
- ( ) Prepare the gripper motor lead ends to 1/8".
- ( ) Similarly, slide the other 6" piece of flexible sleeving over these motor leads as before. Leave 1" of the leads extending past the end of the sleeving.
- ( ) Set the gripper assembly aside temporarily.



**PICTORIAL 2-13**





Refer to Pictorial 2-14 (Illustration Booklet, Page 11) for the following steps.

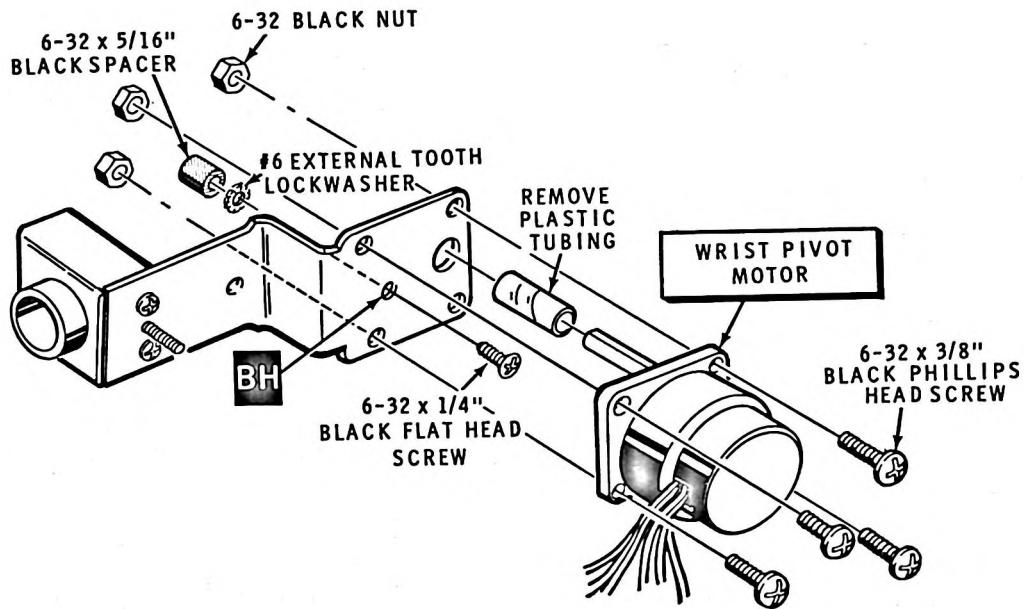
Refer to Detail 2-14A for the following four steps.

- ( ) Position the motor mounting bracket as shown.
- ( ) Mount the motor mounting bracket to the top outside mounting holes (there are three offset mounting holes in the top) in the wrist bracket. Install six 4-40 × 1/4" nuts into their wrist bracket indentations before you mount the bracket at BC and BD with two 4-40 × 1/4" black phillips head screws.

- ( ) Use the medium allen wrench to install a 4-40 × 13/16" allen setscrew into top center hole BE of the motor mounting bracket. Turn the screw into the hole until it is just even with the inside edge of the wrist bracket hole.
- ( ) Similarly install a 4-40 × 5/16" black allen setscrew into bottom center hole BF of the wrist bracket with the #4 allen wrench. Keep the setscrew just even with the inside edge of the wrist bracket as before.

Refer to Detail 2-14B for the following steps.

- ( ) Mount a 6-32 × 5/16" black spacer at motor mounting bracket hole BH with a 6-32 × 1/4" black flat head screw and a #6 external tooth lockwasher. Position the lockwasher between the bracket and the spacer.
- ( ) If it is installed, remove the plastic tubing from over the wrist pivot motor shaft. Mount the wrist pivot motor to the motor mounting bracket with 6-32 × 3/8" black phillips head screws, and 6-32 black nuts.



**Detail 2-14B**

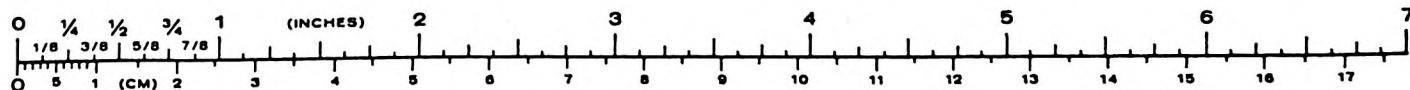
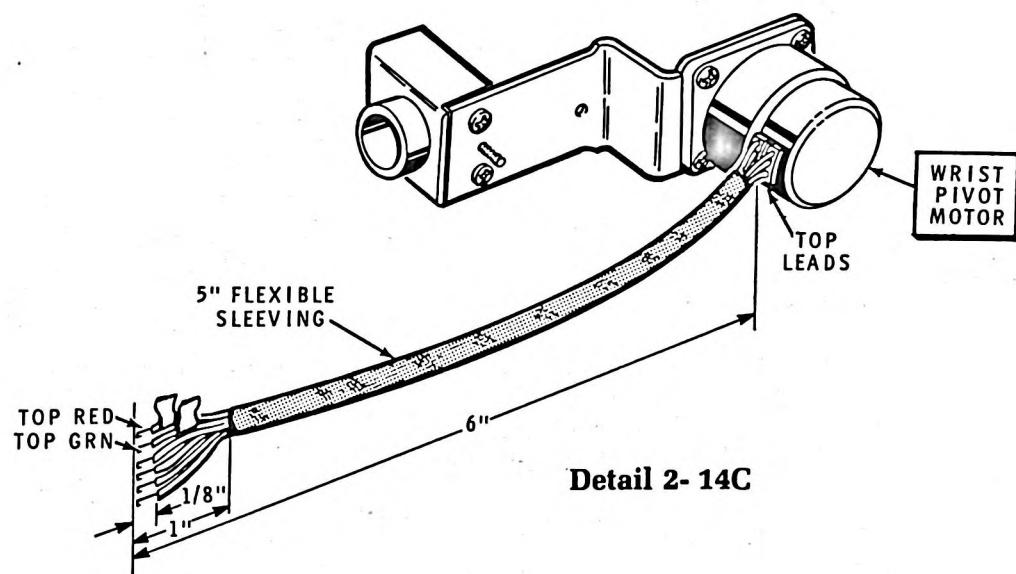
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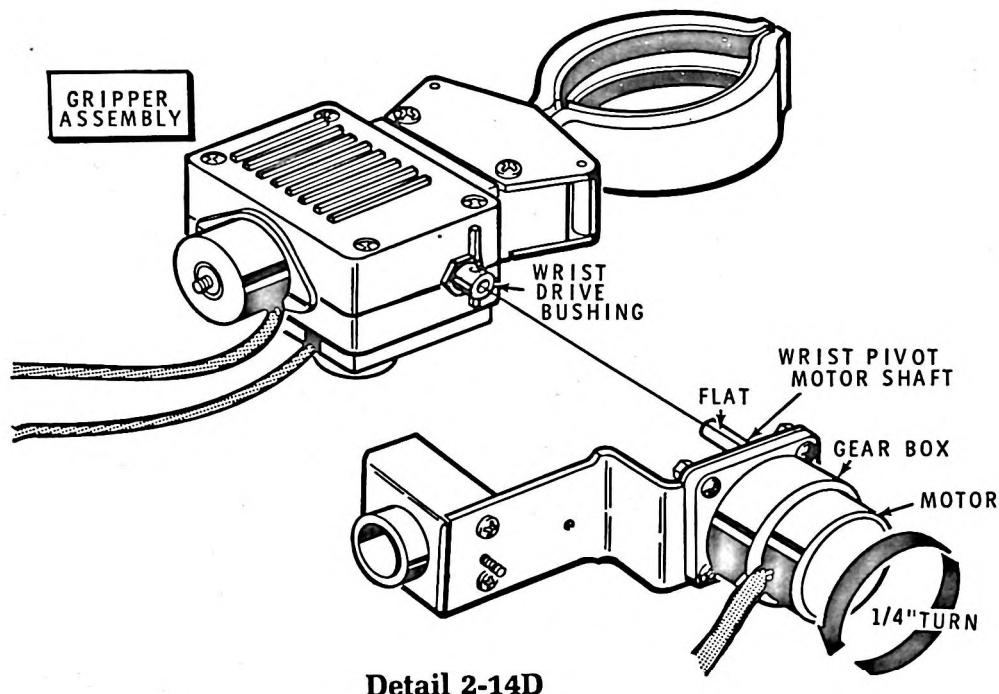
Refer to Detail 2-14C for the following steps.

- ( ) Cut the wrist pivot motor leads to 6".
- ( ) Prepare the *top* red and green wrist pivot motor lead ends.
- ( ) Cut a 5" piece of flexible sleeving.
- ( ) Slide the 5" flexible sleeving over all of the wrist pivot motor leads.

- ( ) Cut two 1/2" pieces of tape.
- ( ) Wrap 1/2" pieces of tape around the prepared top red and green motor leads.
- ( ) Prepare the remaining wrist pivot motor leads.

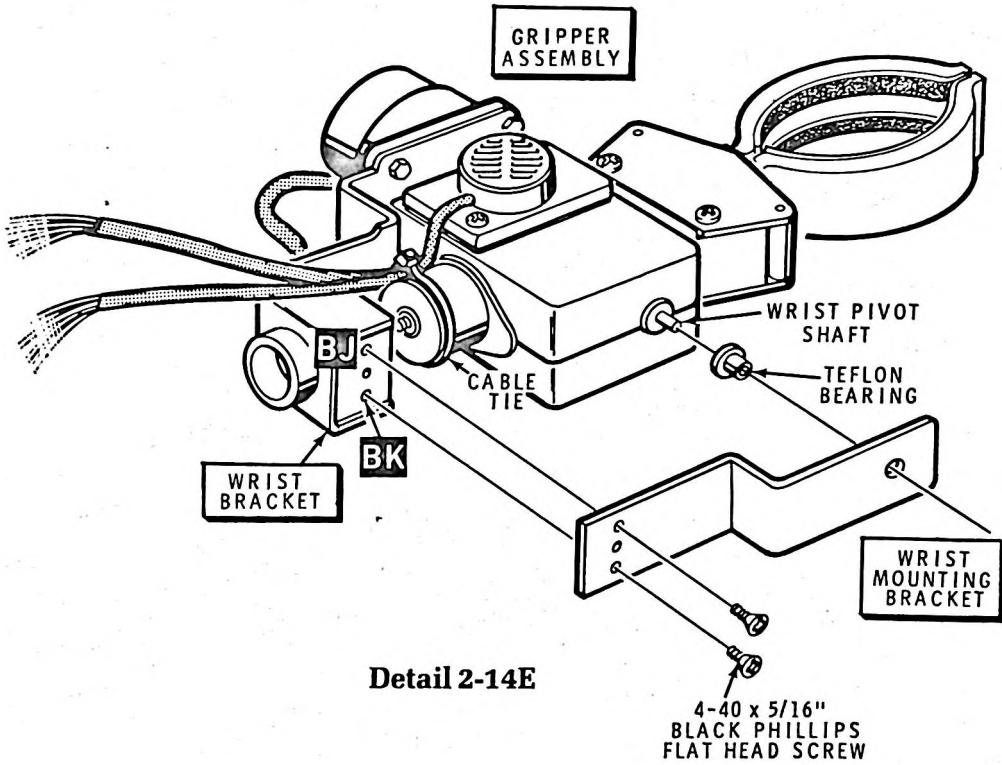


- ( ) Refer to Detail 2-14D and insert the wrist pivot motor shaft into the wrist drive bushing as far as it will go and tighten the bushing setscrew against the motor shaft flat. NOTE: If the wrist pivot motor shaft is improperly positioned, remove the motor from the gear box by twisting it counterclockwise  $\frac{1}{4}$ " turn. The shaft can now be turned as necessary. When you have tightened the setscrew on the shaft of the wrist drive bushing, reinstall the motor by reversing the removal procedure.



**Detail 2-14D**

- ( ) Refer to Detail 2-14E and insert a Teflon bearing over the wrist pivot shaft in the gripper assembly. Then mount the wrist mounting bracket at BJ and BK to the plastic wrist bracket with 4-40 nuts and 4-40 × 5/16" black phillips flat head screws.
- ( ) Refer to Detail 2-14E and install a cable tie around the wrist rotate and gripper motor leads. Position the leads as shown, pull the cable tie tight, and then cut off the excess cable tie.
- ( ) Remove the backing paper from the round decorative label and press the label onto the wrist pivot motor as shown.

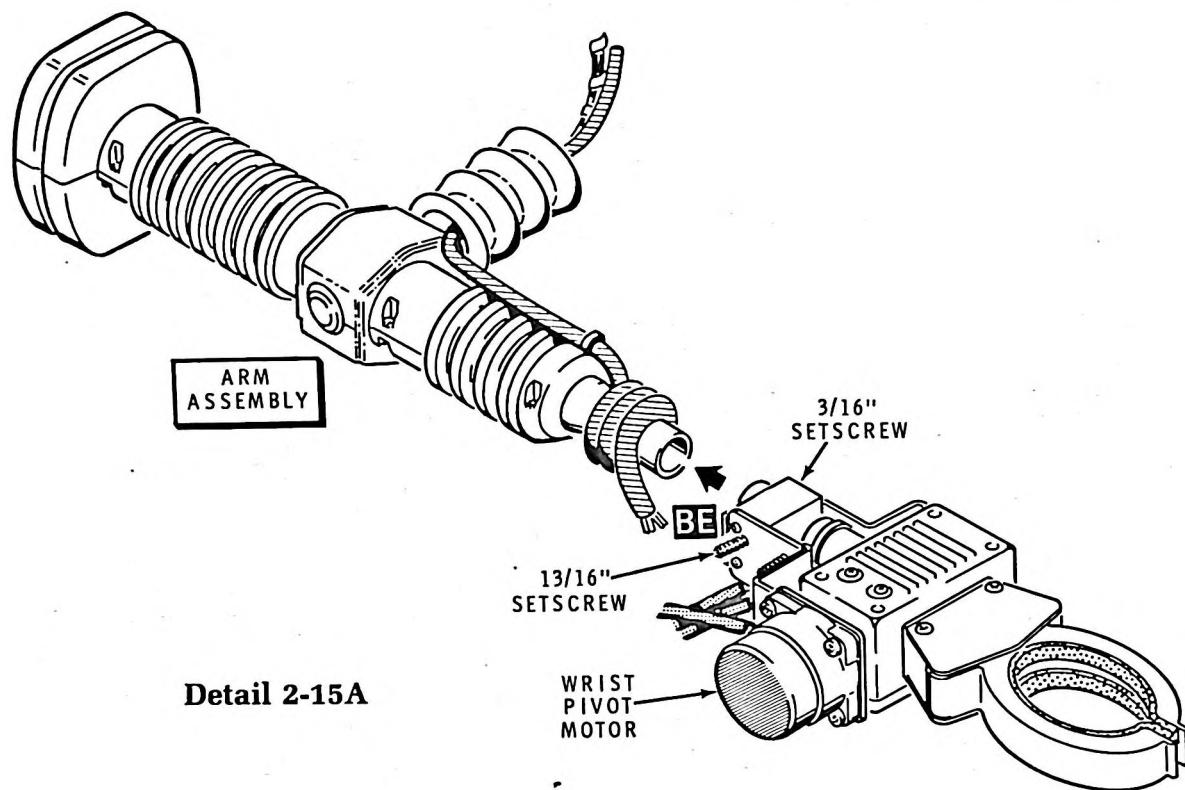


Refer to Part A of Pictorial 2-15 (Illustration Booklet, Page 12) for the following steps.

- ( ) Refer to Detail 2-15A and insert the end of the tubing from the arm assembly into the wrist bracket hole as far as it will go. Position the wrist pivot motor perpendicular to the arm and tighten the  $13/16"$  and the  $3/16"$  setscrews with the medium allen wrench.
- ( ) Position the arm assembly between two books so the wrist pivot motor is upright.

Refer to Detail 2-15B and mount the wrist circuit board to the motor mounting bracket as follows:

- ( ) 1. Install a  $7/32"$  round spacer over the setscrew at BE. Then install another  $7/32"$  round spacer over a  $4-40 \times 7/16"$  black philips flat head screw at BG. Hold this hardware in place with your finger.
- ( ) 2. Slide the wrist circuit board over the hardware at spacers BE and BG with the foil side up and the indicated numbers as shown. Then mount two  $4-40 \times 9/32"$  round threaded spacers at BE and BG to secure the circuit board to the motor mounting bracket.



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**NOTE:** In the following steps, you will connect the motor leads to the wrist circuit board. Since these wires are somewhat stiff, they are difficult to keep stationary. Therefore, it would be easier to have someone hold these leads in place while you solder them to the circuit board holes. Solder each lead after you connect it to a circuit board foil. Position the insulation  $1/16"$  above the foil to make soldering easier. Since these lead wires are so thin, do not leave any more bare wire exposed than necessary, otherwise, the leads will break loose from the circuit board. Also, when you solder a lead or a wire, be careful not to burn any adjacent leads with your soldering iron.

Refer to Part A of Pictorial 2-15 and connect the wrist pivot motor leads to the wrist circuit board as follows:

- ( ) Taped red lead at hole 7.
- ( ) Other red lead at hole 10.

( ) Taped green lead at hole 8.

( ) Other green lead at hole 9.

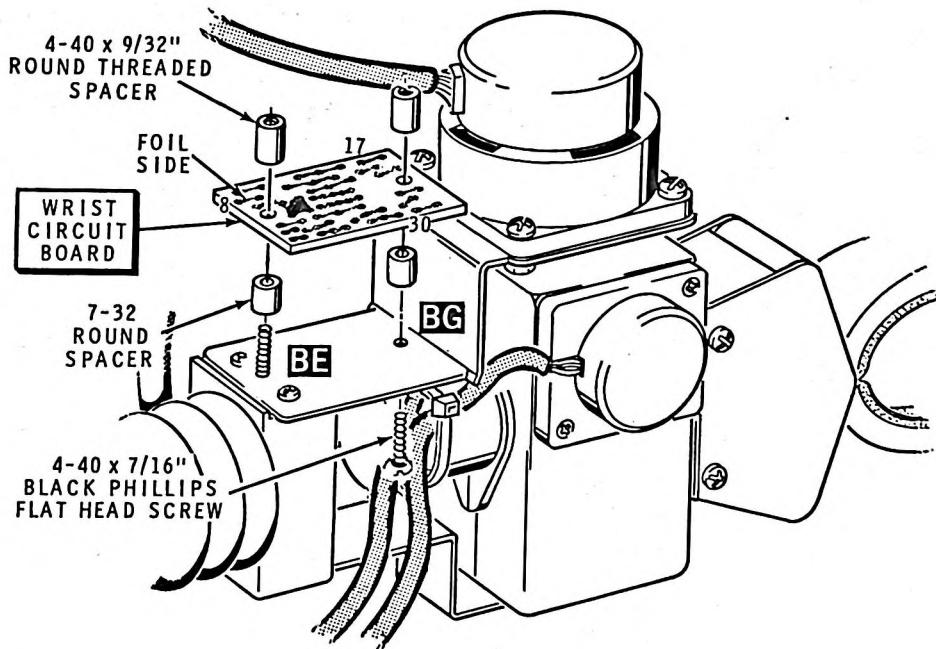
( ) Either black lead at hole 11.

( ) Other black lead at hole 12.

Refer to Part B of Pictorial 2-15 (Illustration Booklet, Page 12) for the following steps.

Connect the gripper motor leads to the wrist circuit board as follows. Solder each lead after you connect it.

- ( ) Either red lead at hole 21.
- ( ) Other red lead at hole 22.
- ( ) Gray lead at hole 25.
- ( ) Green lead at hole 26.
- ( ) White lead at hole 23.
- ( ) Blue lead at hole 24.



Detail 2-15B

Refer to Part C of Pictorial 2-15 (Illustration Booklet, Page 12) for the following steps.

Connect the leads coming from the wrist rotate motor to the wrist circuit board as follows. Solder each lead to the circuit board after you connect it.

- ( ) Black lead at hole 18.
- ( ) Yellow lead at hole 17.
- ( ) Orange lead at hole 19.
- ( ) Either red lead at hole 15.
- ( ) Other red lead at hole 16.
- ( ) Brown lead at hole 20.

Refer to Part D of Pictorial 2-15 (Illustration Booklet, Page 12) for the following steps.

Connect the 10-wire spiral cable wires to the wrist circuit board as follows. Solder each wire to the circuit board after you connect it.

- ( ) Brown wire at hole 2.
- ( ) Red wire at hole 3.
- ( ) Green wire at hole 4.
- ( ) Black wire at hole 1.
- ( ) White wire at hole 5.

- ( ) Violet wire at hole 6.
- ( ) Yellow wire at hole 31.
- ( ) Blue wire at hole 32.
- ( ) Orange wire at hole 33.
- ( ) Gray wire at hole 34.

Refer to Pictorial 2-16 (Illustration Booklet, Page 13) for the following steps.

NOTE: When you perform the following step, it is easy to break the motor leads loose from the circuit board as you position them in their proper locations. Therefore, be very careful when you move the leads.

- ( ) Carefully remove the wrist circuit board from the spacers and turn it over. Cut off any long pigtail leads that could touch together or short to an adjacent diode.
- ( ) Re-mount the wrist circuit board to spacers BE and BG with the foil and lead side up as before.
- ( ) Mount the circuit board cover to spacers BE and BG with 4-40 × 3/16" black phillips head screws. Route the motor wires out the cover openings as shown. Be careful not to break any of the leads loose as you position the cables out of the cover cutouts. Keep the 10-wire spiral cables' outer insulation just inside the cutout as shown in the inset drawing.

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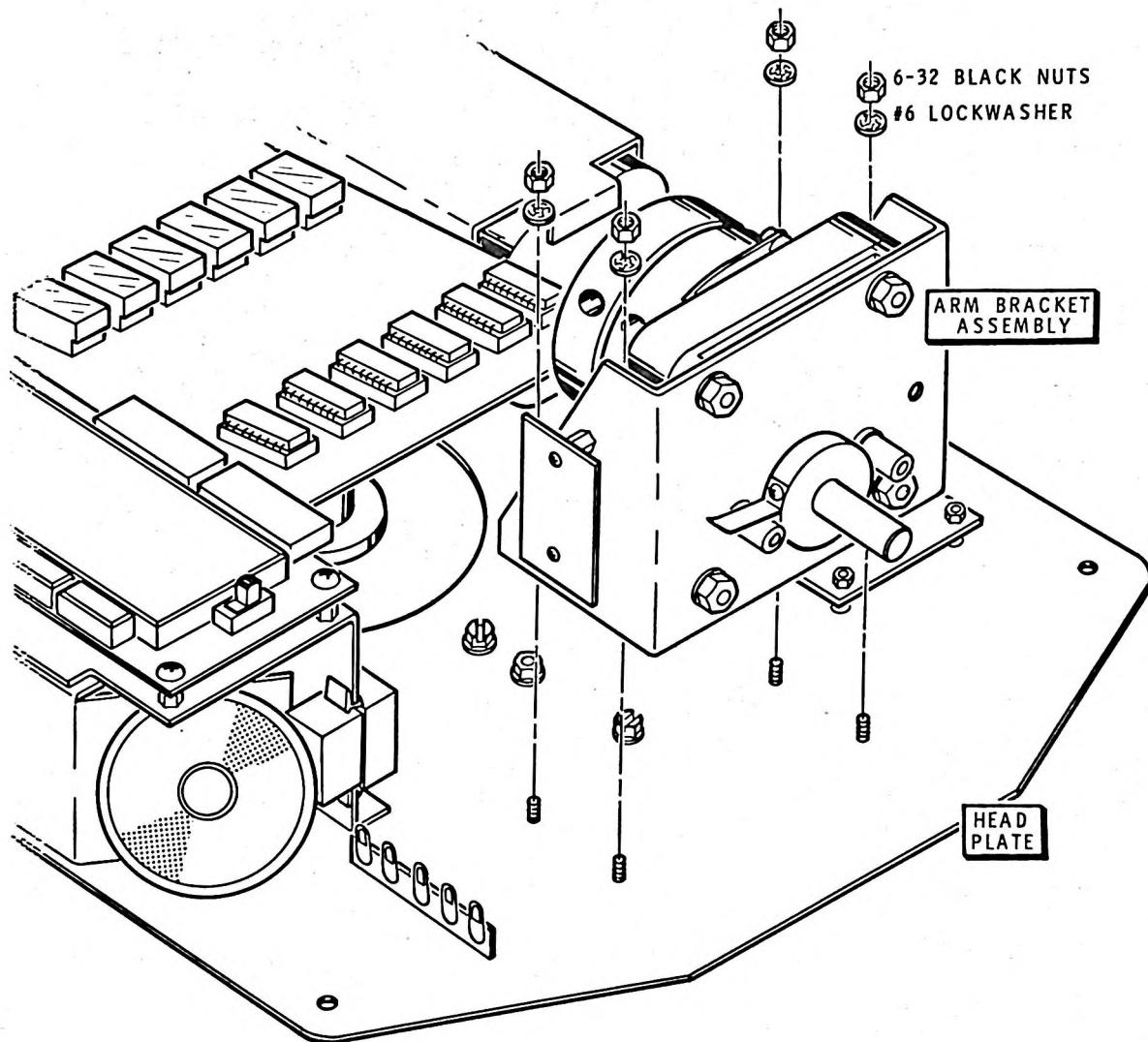
## ARM INSTALLATION

Refer to Pictorial 2-17 (Illustration Booklet, Page 13) for the following steps.

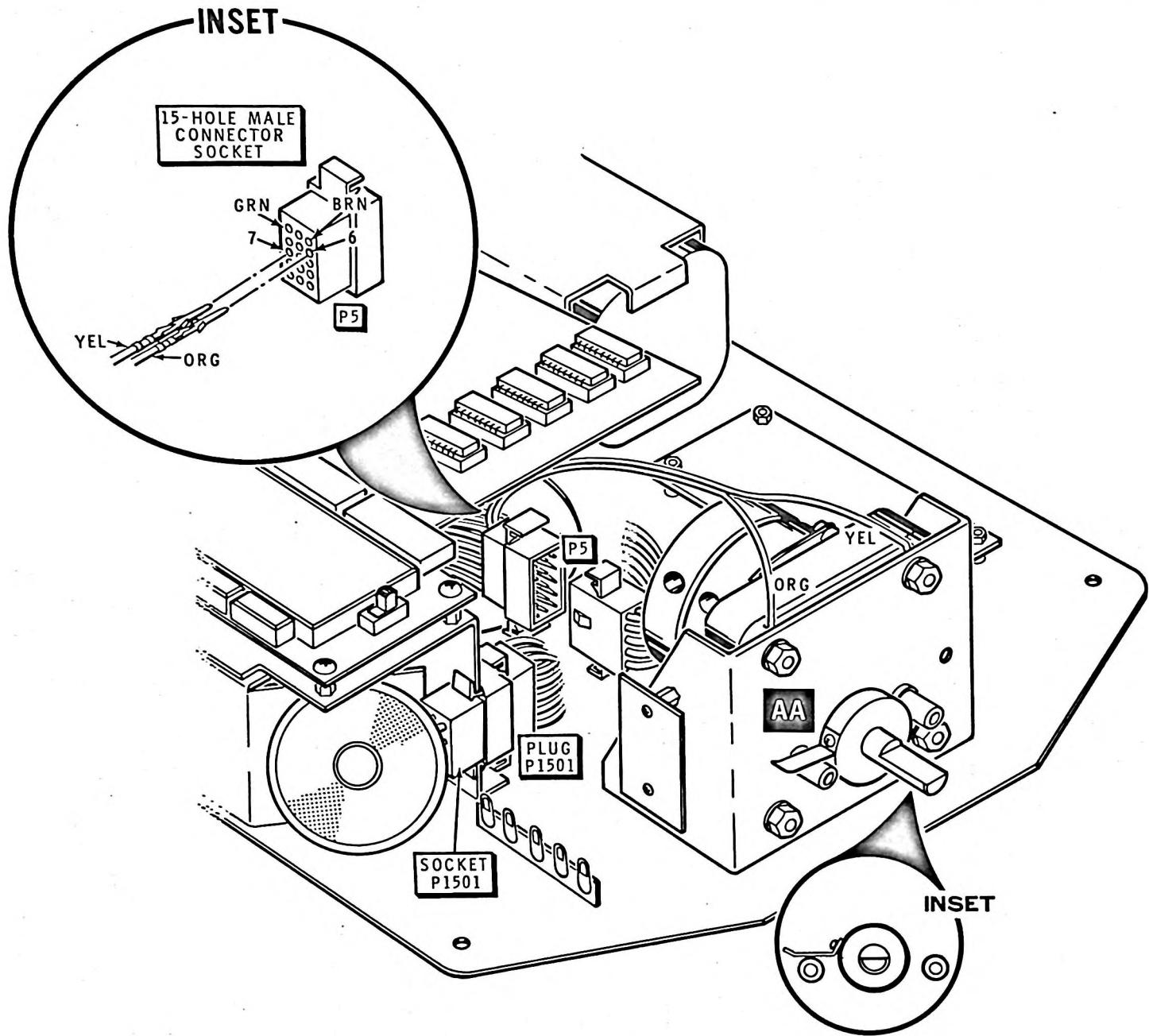
**NOTE:** If you are installing the optional Robot Arm at the same time you are assembling the Robot body, skip the following two numbered steps. If you are installing the optional Arm in a Robot which you assembled at an earlier time, perform the following two numbered steps.

- ( ) 1. Remove the head panel from the Robot.
- ( ) 2. Remove and discard the indicated label from the head panel.

- ( ) Remove the backing paper from the arm decorative label and install the label onto the head panel. Then set the head panel and hardware aside.
- ( ) Refer to Detail 2-17A and mount the arm bracket assembly to the head plate mounting studs with 6-32 black nuts and #6 lockwashers. Use the 1/4" end of the plastic nut starter to start the nuts onto the studs.



Detail 2-17A

**Detail 2-17B**

Refer to Detail 2-17B for the following steps.

**NOTE:** When you perform the following steps, you may find it easier to remove the hardware from the display circuit board and lay the circuit board to the side.

- ( ) Disconnect the socket and plug at P5.
- ( ) Insert the male pin on the end of the orange wire coming from the shoulder motor at socket hole 6, and insert the yellow wire pin at hole 7.
- ( ) Reconnect the socket and plug at P5.
- ( ) Connect plug P1501 from the arm bracket assembly with socket P1501 from the robot harness.

**NOTE:** If you removed the display circuit board from the robot, reinstall it at this time.

Before you mount the Robot Arm onto the shoulder motor shaft, the flat of the shaft must be positioned correctly. Refer to the inset drawing of Detail 2-17B and see if the flat of the shoulder motor shaft on your unit is positioned as shown. If it is positioned as shown, skip the following section entitled "Shoulder Motor Preset" and proceed to "Arm Installation." If it is not as shown, proceed to the following section.

### SHOULDER MOTOR PRESET

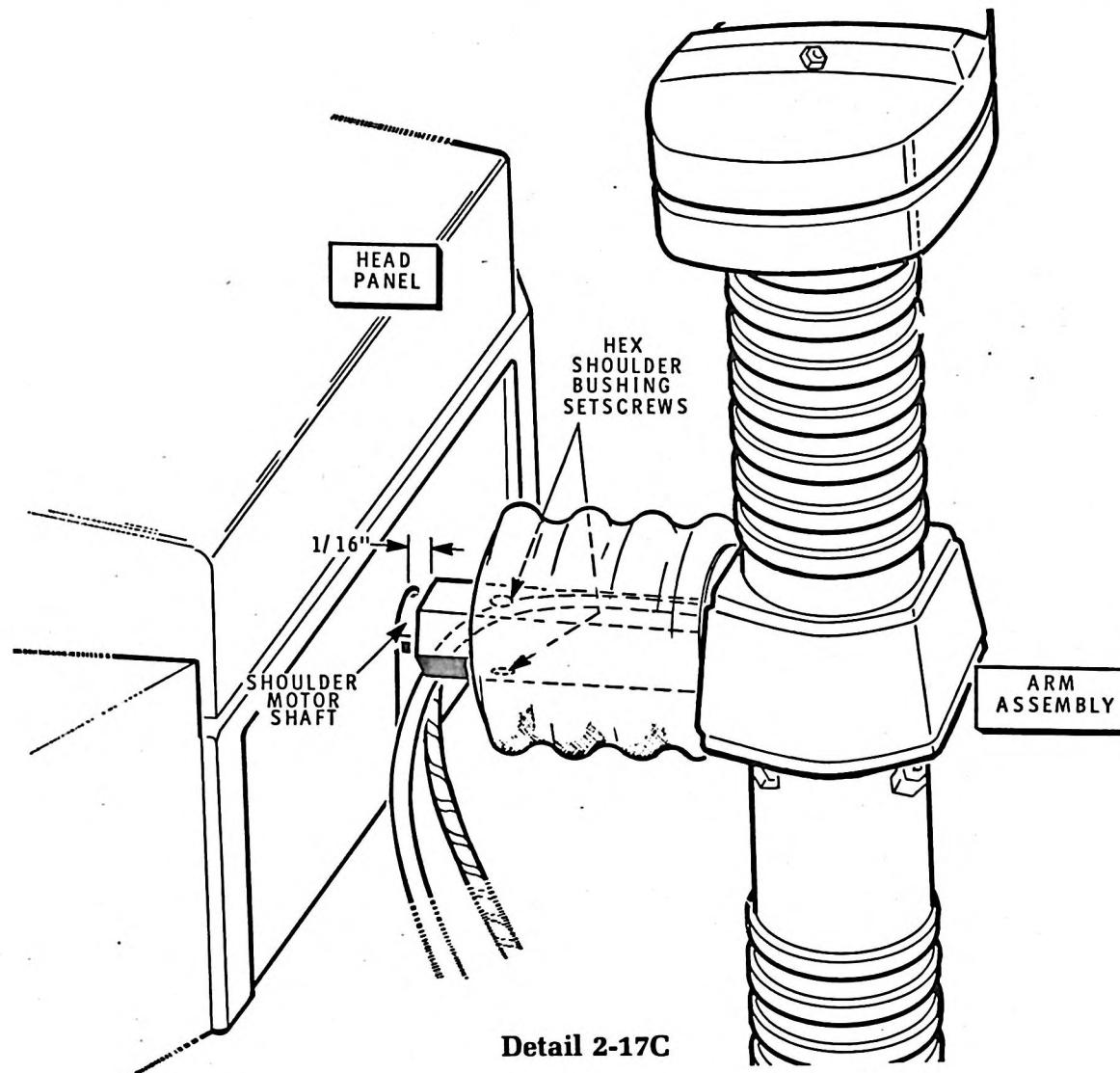
Refer to Pictorial 3-3 (Illustration Booklet, Page 15) for the following steps.

- ( ) Plug the teaching pendant into the Robot torso as shown.
- ( ) Turn the Robot's main Power switch on. You should hear the comment "Ready" (if you have installed the voice circuit board in the Robot). Disregard any of the display indications at this time.

Press the following keys:

- (a) **Reset.**
- (b) **1.**
- (c) **E.**
- (d) **0 - 0 - 0 - 1.**
- (e) **C.**
- (f) **4 - 0.**
- (g) **Reset.** You should hear the comment "Ready."
- (h) **4.**
- ( ) Turn the teaching pendant rotary switch to **ARM PIVOT** and the FUNCTION switch to **ARM**.
- ( ) Press the teaching pendant's trigger switch and hold it in.
- ( ) Press the MOTION switch to the left or right, depending on the direction you wish to turn the shoulder motor shaft. When the flat of the shaft is positioned correctly, release the MOTION and the trigger switches. NOTE: If the motor stops before the flat of the shaft is positioned correctly, the arm actuator may be against one of the contact spacers. If this happens, loosen the setscrew on the round bushing and position the actuator so the shaft flat can be positioned properly. You will reposition the actuator in the next step. If the actuator is not touching one of the spacers, it will be necessary to repeat steps "a" through "h" to start the motor again. You may have to repeat the steps several times before the motor shaft is correctly positioned.
- ( ) Once the flat of the motor shaft is positioned correctly, loosen the round bushing setscrew and position the bushing so the actuator just touches spacer AA as shown in the inset drawing on Detail 2-17B. Slide the actuator bushing over the motor shaft as far as it will go and retighten the setscrew securely.
- ( ) Turn the Power switch off and disconnect the teaching pendant.

Proceed to "Arm Installation."



### ARM INSTALLATION

- ( ) Temporarily mount the head panel onto the robot head plate with the head mounting hardware.
- ( ) Refer to Detail 2-17C and slide the hex shoulder bushing on the arm assembly over the shoulder motor shaft so one of the allen setscrews are next to the flat of the shaft. If the setscrews are into the bushing too far, you will have to loosen the bushing setscrews

slightly to slide it over the shaft. Position the arm so the end of the hex shoulder bushing is approximately  $1/16"$  from the edge of the head shell. First, tighten the bushing setscrew over the flat of the shaft, then tighten the other setscrew last with the large allen wrench. NOTE: It will be necessary to compress one end of the bellows to tighten the hex shoulder bushing setscrews.

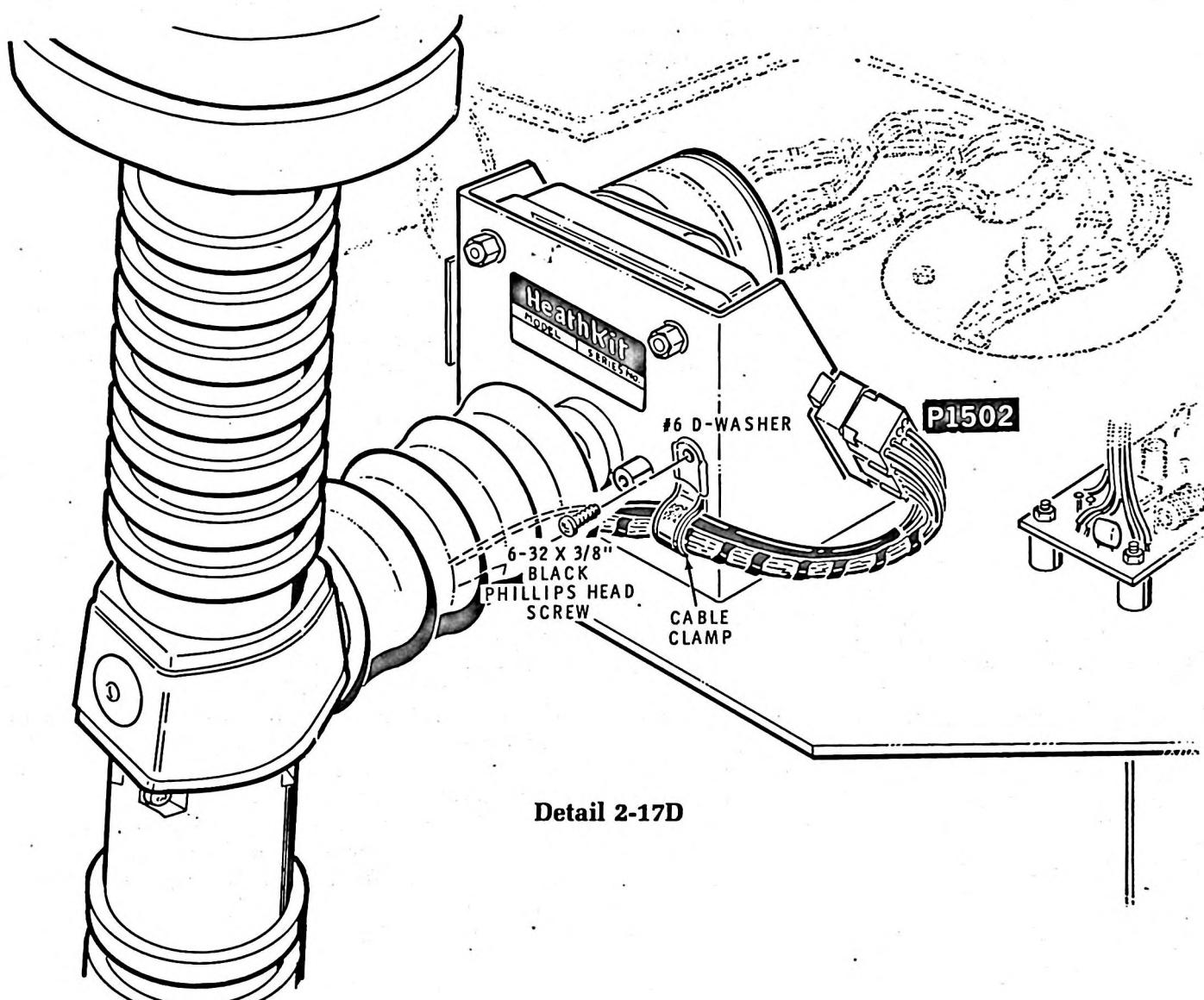
- ( ) Remove the head panel from the robot and set it and the hardware aside.

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( ) Refer to Detail 2-17D and press arm plug P1502 into arm bracket socket P1502.

( ) Refer to Detail 2-17D, install a cable clamp around the arm cables. Mount the cable clamp to the arm bracket with a #6 D-washer and a 6-32 x 3/8" black phillips head screw. Position the clamp as shown. NOTE: Make sure the arm cables are routed along the hex shoulder bushing as shown.

This completes the "Step-By-Step Assembly" of the Robot Arm. Proceed to the "Initial Tests."



## INITIAL TESTS

In this section, you will check the basic functions of the Robot Arm. If you encounter any difficulties during the tests, turn the main power switch off and proceed to "In Case Of Difficulty" before proceeding with any other tests.

Refer to Pictorial 3-1 (Illustration Booklet, Page 14) for the following tests.

### EXECUTIVE MODE

- ( ) Turn the Robot's main power switch on. The following sequence of events should occur:
1. The comment "Ready" should be heard (if you have the optional voice circuit board installed in the Robot).
  2. The display should show "HEro 1.0" for approximately ten seconds, after which a moving dash will be displayed.

The Robot is now in the "Executive" mode of operation. Proceed to the next test.

### INITIALIZE MODE

This mode of operation will check each function of the Robot Arm automatically.

Each of the Robot's stepper motors has two limits of travel. For example, the shoulder motor can drive the arm approximately 150 degrees between the upper and lower limits of its travel; the gripper motor can move the gripper from the fully closed position to a maximum opening of 3-1/2"; and so on.

The Robot CPU controls the arm movements. However, before the CPU can exercise control of the arm, it must first know the arm's exact position, and since the arm can be in any position before you turn on the main power switch, the arm motors have to be preset to known positions. This is the purpose of the Initialize Mode. It successively drives each stepper motor to its limit, and then reverses direction and presets the various moving elements of the Robot to a known position. After that, the CPU will assume command.

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**Always perform the Initialize Mode whenever you first power up the Robot.**

The motors which drive the steering, head, and shoulder have built-in limit switches to stop the motors whenever their limits are reached. The remaining motors do not have limit switches. Therefore, when you begin the Initialize Mode, it is assumed that the motors without the limit switches are at their opposite limit of travel (even if they are not). When you begin the initialization, the CPU sends out a sufficient series of pulses to bring each one of the stepper motors to its reference limit. This may result in one or more of the motors, without the limit switches, to be driven to their mechanical stop before

the driving pulses are completed, causing the motor(s) to slip. (During that time, the motors will hum and appear to be stuck.) However, the motors are designed to withstand this initialization slippage without any damage.

**NOTE:** In the following steps, if a motor continues to run long after the mechanical stop has been reached, or if the Robot head and arm is not positioned as shown in Pictorial 3-2 (Illustration Booklet, Page 14), press the reset button (see Pictorial 3-2) and refer to "In Case Of Difficulty" on Page 59.

Refer to the following chart to Initialize the Robot.

| KEYBOARD ENTRY | DISPLAY    | FUNCTION  |
|----------------|------------|---|
| <b>31</b>      | <b>3.1</b> | <p>The motors will operate in one direction to their limit of travel, (unless they happen to be at that position already), and then reverse until the head and steering wheel point straight forward, the arm points straight down with the wrist pivot and rotate positions centered, and the gripper is closed.</p> <p>When the initialization sequence is complete, you should hear the word "ready" (if the voice option is installed). The display will read "HEro 1.0" for approximately 10 seconds and then change to a moving dash.</p> |

The initialization is now complete. If you did not have any problems, proceed to "Manual Mode."

## MANUAL MODE

Refer to Pictorial 3-3 (Illustration Booklet, Page 15) for the following steps.

The Robot Arm can be operated with the teaching pendant as follows.

1. Plug the teaching pendant into the Robot torso as shown.
2. Turn the teaching pendant rotary switch to N (neutral) and the FUNCTION switch to ARM.
3. Press the **4** key on the keyboard. The left digit should indicate **4**.

**NOTE:** Each position of the stepper motors is stored as a number in the Robot's memory system. As each motor moves, its number is automatically updated by the CPU. When you are in the Manual Mode, this relative number is displayed at the two far right digit positions.

4. Since you have just completed the initialization routine, use the teaching pendant's rotary switch and, one at a time, select the HEAD, EXTEND, ARM PIVOT, WRIST PIVOT, ROTATE, and GRIP positions. The Robot will remain stationary, however, at each position of the switch, the **two far right digits** will indicate a number relative to that switch function. For the Initialization routine you performed, these values are as follows:

| SWITCH POSITION | DISPLAY READOUT |
|-----------------|-----------------|
| HEAD            | 62              |
| EXTEND          | 00              |
| ARM PIVOT       | 00              |
| N (NEUTRAL)     | BLANK           |
| WRIST PIVOT     | 00              |
| WRIST ROTATE    | 4d              |
| GRIPPER         | 00              |

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5. Select the ARM PIVOT position on the rotary switch.
6. Press the teaching pendant's trigger switch and hold it in. As you press the trigger switch, press the MOTION switch to the RIGHT to raise the arm. Note that as the arm is raised, the numbers in the two far right digits increase. Once the arm is raised, release the MOTION switch but continue to press the trigger switch.
7. Press the MOTION switch LEFT to lower the arm. The numbers to the right of the display should decrease as the arm moves down.
8. Select each of the arm and wrist movement functions on the rotary switch and verify that the movement can be controlled in both directions and that the numbers displayed at the far right change with the movements. Once each arm movement reaches some random position, leave it there.
9. Press the keyboard RESET button to exit the MANUAL mode and re-enter the EXECUTIVE mode. You should hear the word "ready" (if the voice option is installed). The display will read "HEro 1.0" for approximately 10 seconds and then change to a moving dash.
10. Rotate the teaching pendant rotary switch to the "N" position.
11. Press the keyboard 3 and 2 buttons. Each Arm function should return to its "home" position, after which you should hear the word "ready" (if the voice option is installed). The display will read "HEro 1.X\*" for approximately 10 seconds and then change to a moving dash.

This completes the "Initial Tests." If you have purchased the "Voice" option with the Robot, proceed at this time to that Manual; otherwise, proceed to "Final Assembly."

\* "X" means that the readout may be any figure.

## FINAL ASSEMBLY

Refer to Pictorial 3-4 for the following steps.

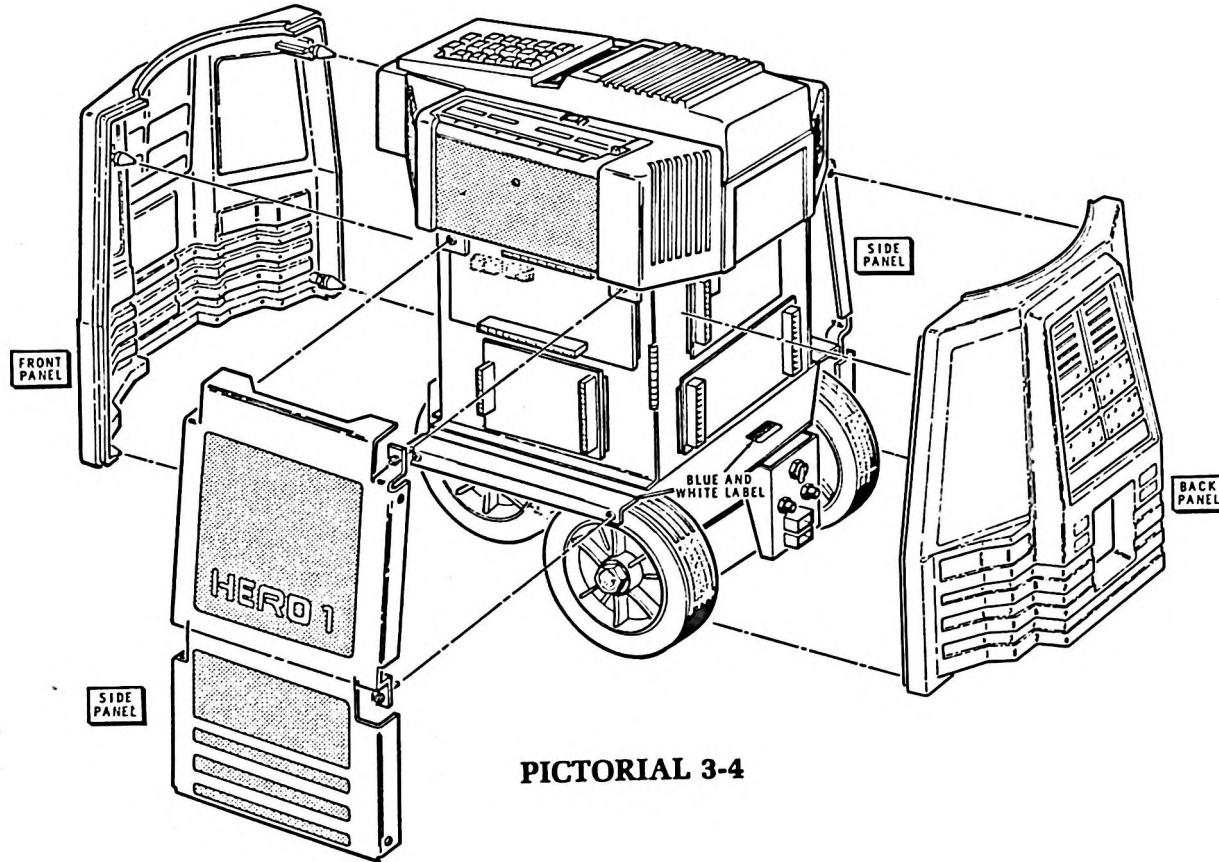
NOTE: If you have already installed any or all of the body panels on your Robot, skip the first three steps that instruct you to install them.

- ( ) Mount the aluminum body side panels onto the Robot torso as shown.
- ( ) Mount the body front panel to the Robot torso.

( ) Mount the body rear panel to the Robot torso.

( ) Use the flathead screws supplied with your Robot and mount the head panel to the head plate at the four locations shown.

This completes the "Final Assembly." Proceed to "Operation."



**PICTORIAL 3-4**

# OPERATION

This section of the Manual will explain the remaining two modes of operation for the Robot Arm: "Learn" and "Repeat." The explanations are basic and easy to use. They are intended to help the person who is unfamiliar with computer language obtain a program to use with the Robot Arm and perform some basic tasks. While these tasks can be somewhat varied by

the user, they are quite limited at this stage. After you have completed this operation section and are comfortable with it, you can then proceed with the more advanced, complex programs as outlined in the "Operation Manual," which you received with the Robot. These programs will show you how to program and operate the Robot in conjunction with its accessories.

## LEARN MODE

In the Learn mode, you control the arm movements with the teaching pendant just as you did in the Manual mode. The difference is that, now, all of the movements will be stored into the Robot's memory so that you can repeat them.

To select the Learn Mode, use the following chart:

| KEYBOARD   | DISPLAY ENTRY |
|------------|---------------|
| Press 7    | 7. ----       |
| Press 0200 | 7. ----       |
| Press 0500 | 7F0208        |

1. Using the teaching pendant, press the trigger switch and hold it in. NOTE: You must always press this switch whenever you wish to engage the teaching pendant function.
2. Press the MOTION switch and preset each of the arm and wrist motors to some desired position. Each time the arm or wrist reaches your preset position, release the MOTION switch and turn the rotary switch to select the next position. Note that each time you release the MOTION switch to stop an arm or wrist motion, its relative number (or it could be a letter designation) changes. Each new movement (value) is stored into memory so it can be repeated later.
3. Press the keyboard RESET button and the word "ready" should be heard (if the voice option is installed). The display should show "HEro 1.0" for approximately ten seconds; after which a series of moving dashes will be displayed.

Your arm movement program is now stored in the Robot's memory. Proceed to the "Repeat Mode."

## REPEAT MODE

In the "Repeat Mode," the Robot will execute the program you just stored with the teaching pendant.

Use the following chart to select the Repeat Mode:

| KEYBOARD ENTRY      | DISPLAY    | FUNCTION  |
|---------------------|------------|---|
| Press <b>A</b> .    | <b>A</b>   |   |
| Press <b>D</b> .    | ---do.     |   |
| Press <b>0200</b> . | None       | The arm and wrist will first return to their "home" positions. As soon as all of the functions reach home, the program sequence you chose in the Learn Mode will begin. Each movement will be in the order you chose with the teaching pendant. When the arm reaches the point where the program stops, the word "ready" will be heard (if the voice option is installed) and it Robot will return to the "Execute Mode." The arm should now be at the position it was when you completed the "Learn Mode." |
| Press <b>32</b>     | <b>3.2</b> | The arm should return to its "home" position.   |

This program is now stored in the Robot's memory so that you can repeat it whenever you wish. Simply follow the keyboard entries in the "Repeat Mode" chart. You can use the Learn and Repeat modes to program the Robot Arm and perform several tasks, such as picking up a can from a table. Once you become familiar with programming the arm, proceed to the "Operation Manual."

This completes the "Operation."

# IN CASE OF DIFFICULTY

## GENERAL

### VISUAL CHECKS

1. All the motions of the Robot Arm should be smooth and continuous. If there is any mechanical binding in the mechanism, the associated motor is likely to stall. Check the assembly portion of the Manual to make sure the installation of the part is as shown, and, if applicable, the correct mounting hardware is used.
2. About 90% of the kits that are returned for repair, do not function properly due to poor connections and soldering. Therefore, you can eliminate many troubles by carefully inspecting connections to make sure they are soldered as described in the Soldering section of the Assembly Notes. Reheat any doubtful connections and be sure all the wires are soldered at places where several wires are connected.
3. Check to make sure all diodes are installed correctly.

4. Recheck the wiring. Trace each lead in colored pencil on the Pictorial as you check it. It is frequently helpful to have a friend check your work. Someone who is not familiar with the unit may notice something you have consistently overlooked.
5. Check all of the diode leads connected to the circuit boards. Make sure the leads do not extend through the circuit board and make contact with other leads or the metal parts.

### HOW TO TROUBLESHOOT YOUR ROBOT ARM

If you know which area the trouble lies, apply the Visual Tests listed to that area.

You may also go directly to the Troubleshooting Chart to see if the difficulty is described in one of the "Condition" columns. If your difficulty is listed there, check the "Possible Causes" for that item and apply the Visual Checks listed to the area of difficulty.

In an extreme case where you are unable to resolve a difficulty, refer to the "Customer Service" information inside the rear cover of the Manual. Your Warranty is located inside the front cover.

## TROUBLESHOOTING CHART

| <b>PROBLEM</b>  | <b>POSSIBLE CAUSE</b>  |
|---|--|
| Arm motor will not operate.   | <ol style="list-style-type: none"> <li>1. Motor at its electrical stop.</li> <li>2. Mechanical bind.</li> <li>3. Broken motor wire(s).</li> <li>4. Incorrect motor wiring.</li> <li>5. Incorrect or missing logic pulses.</li> </ol>               |
| Arm motor hums or jitters, but does not move.   | <ol style="list-style-type: none"> <li>1. Motor at its mechanical stop.</li> <li>2. Mechanical bind.</li> <li>3. Broken motor wire(s).</li> <li>4. Incorrect motor wiring.</li> <li>5. Incorrect logic pulses.</li> </ol>                          |
| Motor operates backwards.   | <ol style="list-style-type: none"> <li>1. Incorrect motor wiring. NOTE: Any of the arm motors may operate in one direction only after power-up until the Robot runs its "initialize" program (3.1).</li> <li>2. Incorrect logic pulses.</li> </ol> |
| Shoulder motor rotates past its electrical stop.  | <ol style="list-style-type: none"> <li>1. Electrical stop wires are reversed.</li> </ol>   |
| One of the arm motors "homes" at the incorrect location, such as the gripper motor not closing all the way. | <ol style="list-style-type: none"> <li>1. Mechanical stop was overdriven during programming.</li> <li>2. Mechanical motor slippage.</li> <li>3. Mechanical bind.</li> </ol>  |
| Wrist rotate motor binds.   | <ol style="list-style-type: none"> <li>1. Incorrect clutch adjustment.*</li> <li>2. Incorrect worm mesh adjustment.</li> <li>3. Incorrect worm bearing adjustment.</li> </ol>  |
| Wrist rotate clutch slips.  | <ol style="list-style-type: none"> <li>1. Incorrect clutch adjustment.*</li> <li>2. Incorrect worm mesh adjustment.</li> <li>3. Incorrect worm bearing adjustment.</li> </ol>  |

\* See Page 61 "Worm Gear Clutch Adjustment".

## WORM GEAR CLUTCH ADJUSTMENT

This section instructs you on how to adjust the worm gear clutch for the proper worm motor torque. To adjust the 5/16" torque adjustment nut, use a 5/16" open end wrench or a pair of long-nosed pliers.

- ( ) Use the teaching pendant and position the arm and the wrist so that the four 4-40 × 3/4" black phillips head screws on the motor housing top are easily accessible.

Refer back to Pictorials 2-10 and 2-11 on Pages 34 and 35 for the following steps.

- ( ) Remove the four 4-40 × 3/4" black screws from the top motor housing and carefully remove the housing top from the housing bottom. NOTE: Hold the wrist drive bushing in place in the motor housing bottom while you remove the housing top.
- ( ) Loosen the two 4-40 × 1/4" black phillips head screws which hold the bearing housing to the motor housing top. Set the housing top and hardware aside.

**NOTE:** Use the following program to actuate the worm motor to adjust the clutch for the proper torque. The worm motor will turn ten times in both directions to allow you sufficient time to make the adjustment. To make the adjustment once the worm motor shaft is actuated perform the following steps:

1. Enter the following program:

```
RESET
1
A
0100
CE 000A
3F
C3 68 93
C3 68 00
83
09
8C 0000
26 F2
3F
3A
```

2. To run the program and actuate the worm motor, enter:

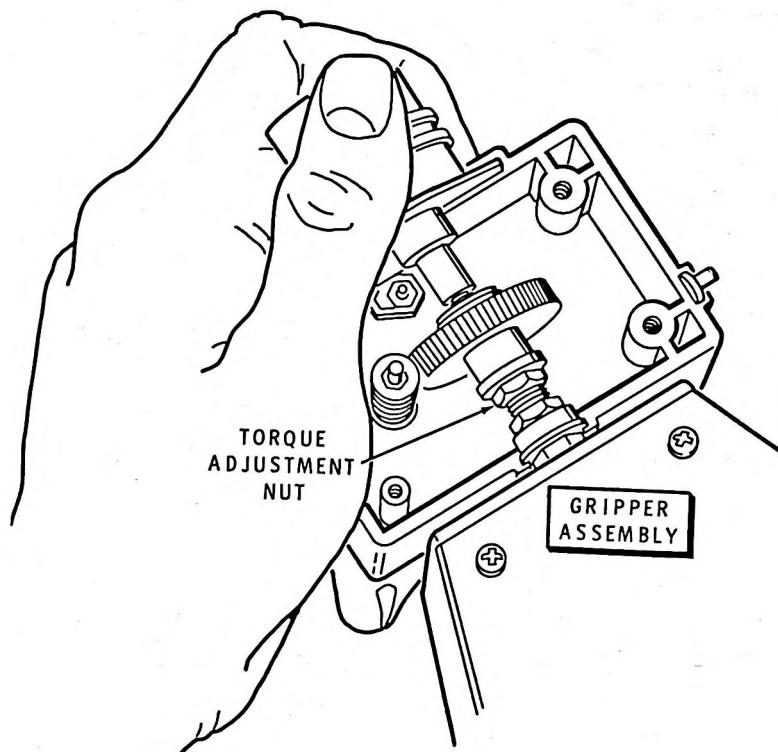
```
RESET
1
D
0100
```

The worm motor will now be actuated and the gripper assembly begin to turn.

Refer to Pictorial 4-1 for the following steps.

3. When the worm gear assembly is in an accessible position, hold the gripper assembly so that it cannot rotate further. Slowly tighten the torque adjustment nut until the worm gear just stops turning. Then loosen the adjustment nut until the worm gear is just able to turn.
4. Once you have completed the adjustment, wait until the gripper assembly is in an accessible position to reinstall the motor housing top. Then press the RESET button to interrupt the program and return to the Executive Mode of operation.
5. Reassemble the motor housing top onto the motor housing bottom.
6. Refer back to step #2 and rerun the program to actuate the worm motor. While the worm motor is operating, tighten the two bearing housing screws when they are in an accessible position. Allow the motor to cycle several times while you check for any more binding. If the motor runs smoothly, press RESET to interrupt the program and return to the Executive Mode of operation. If the motor still binds, you will have to loosen the two bearing screws as many times as necessary so the bearing can position itself correctly and does not bind.

This completes the clutch adjustment.



**PICTORIAL 4-1**

## SPECIFICATIONS

Arm Movements ..... 350° horizontal rotation using the turret motor.

150° vertical plane rotation using the shoulder motor.

5" (12.7 cm) extension and retraction of the gripper using the extender motor.

90° wrist pivot above or below the arm axis (180° total) using the wrist pivot motor.

350° wrist rotation using the wrist rotate motor.  
Gripper opens 3-3/4" (9.53 cm) using the gripper motor.

90° wrist assembly rotation at maximum arm extension (with the curved track option installed).

Maximum Payload:  
Arm horizontal and fully retracted ..... 16 oz. (455 grams).

Arm horizontal and fully extended ..... 8 oz. (227.5 grams).

Gripper Force ..... 5 oz. (142 grams) maximum.

Weight ..... 3 lbs. (1.7 kg).

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The Heath Company reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to incorporate new features in instruments previously sold.

## THEORY OF OPERATION

All of the motors which drive the arm are "stepper" motors. These stepper motors move a discrete amount in response to a digital input signal. The central processor unit (CPU) generates the digital signals which are sent to an arm-drive circuit board to be amplified. These amplified signals are sent to the appropriate drive motor.

In the Manual mode of operation, the CPU detects the teaching pendant's rotary switch position, determines which motor is selected to be driven, generates the digital signals, which moves the selected motor in the desired direction.

In the Learn mode of operation, the CPU detects the teaching pendant's rotary switch position and interprets it just as it did in the Manual mode. However, the CPU now stores (into its memory) which motor was moved, by how much, and in which direction.

In the Repeat mode of operation, the CPU recalls the information it stored into its memory. It then drives each stepper motor in the exact same order, by the same amount, and in the same direction as when they were sequenced in the Learn mode of operation.

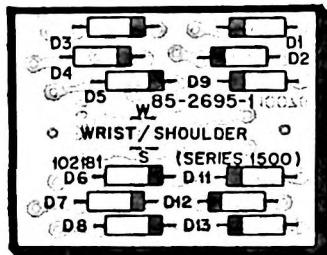
NOTE: For a more detailed description of the Arm and its associated circuitry, refer to the "Technical Manual" which you received with your Robot.

## CIRCUIT BOARD X-RAY VIEW

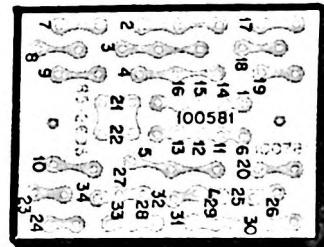
**NOTE:** To find the PART NUMBER of a component for the purpose of ordering a replacement part:

- A. Find the circuit component number (D1, D2, etc.) on the X-Ray View.
- B. Locate this same number in the "Circuit Component Number" column of the "Parts List" in the front of this Manual.

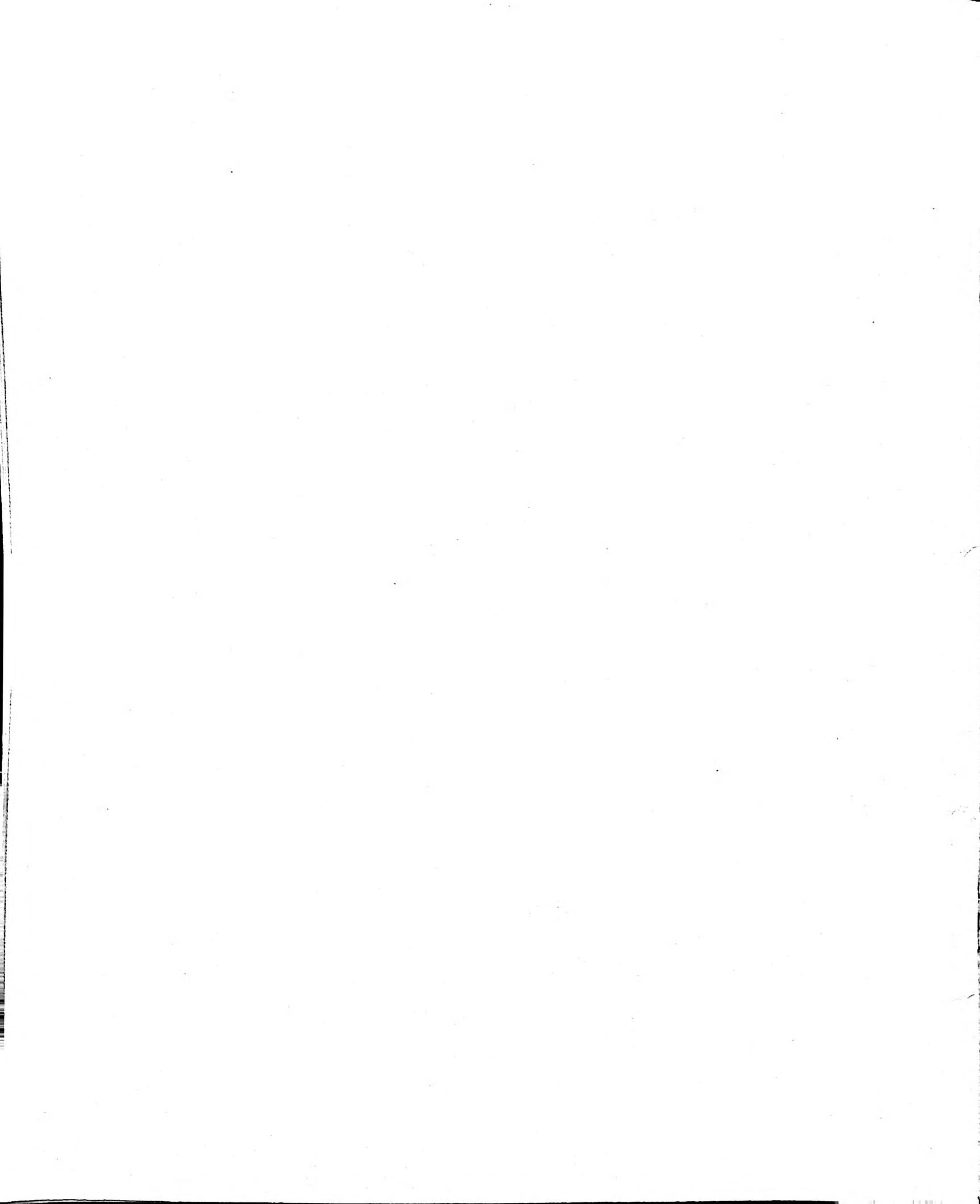
- C. Adjacent to the circuit component number, you will find the PART NUMBER and DESCRIPTION which must be supplied when you order a replacement part.



**Shown From The Component Side**



**Shown From The Foil Side**



# CUSTOMER SERVICE

## REPLACEMENT PARTS

Please provide complete information when you request replacements from either the factory or Heath Electronic 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 ELECTRONIC CENTERS

For your convenience, "over the counter" replacement parts are available from the Heath Electronic 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 Electronic Center.

## 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 consultation 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.**

Heathkit Electronic Center 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 Heathkit Electronic Center. 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. Refer to Heath Company for instructions for sending the entire Robot or large portions of it.

Seal the carton with reinforced gummed tape, tie it with a strong cord, 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

595-2886-04