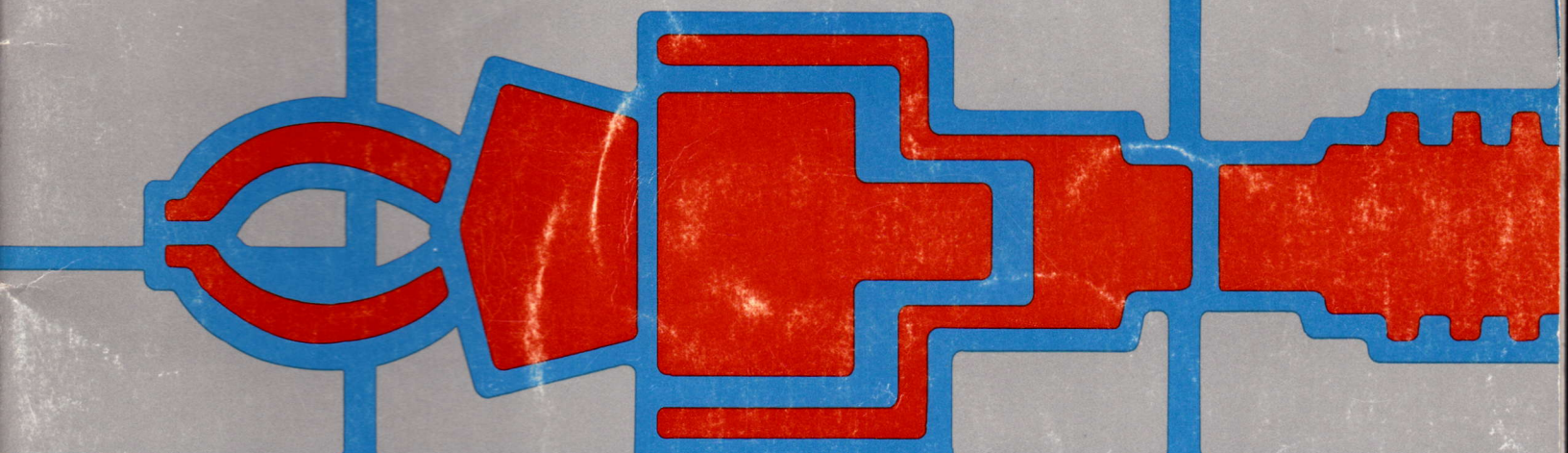
ET-18 ROBOT

REMOTE

OPERATION MANUAL



Heathkit

ZENITH Educational Systems

Heathkit® Manual

for the

REMOTE CONTROL ACCESSORY

Model ET/ETW-18-3

595-3162

WARNING: This instrument is not designed for outdoor use. To prevent fire or shock hazard, do not expose this instrument to rain or moisture.

HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022

Heathkit®

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INTRODUCTION

The ET/ETW-18-3 Remote Control Accessory is designed to be used with the ET-18 Robot. It allows the user to control all of the Robot's teaching pendant and keyboard functions from a remote location.

The receiver section of the ET/ETW-18-3 is an AM superhetrodyne type with a microprocessor decoder. It features a low power mode when not in use to conserve battery power. Whenever the teaching pendant is plugged into the Robot, the transmitter teaching pendant function is bypassed. The ET/ETW-18-3 acessory mounts easily inside the Robot with only a small wire antenna exposed.

The ET/ETW-18-3 has an attractively styled remote unit with a self-contained rechargeable battery which provides enough power for operation up to five hours or more. You can recharge the battery over night using the AC plug-in battery charger that is supplied with the unit.

The transmitter has all of the teaching pendant and hex keyboard controls and also includes an RS-232C port for loading programs into the Robot from a computer. The preassembled transmitter module transmits on the 75 MHz band and has a range of approximately 100 feet via a telescoping swivel-base antenna. The digitally encoded RF signal is microprocessor controlled. The ET/ETW-18-3 is supplied with one of three available RF transmitter modules.

PARTS LIST

The Accessory is shipped in two cartons. The smaller of the two contains the crystal and transmit module. The other contains the remaining parts. Open both cartons and remove the parts. Check each part against the following list. The key numbers correspond to the numbers on the "Parts Pictorial" (Illustration Booklet, Page 1). Do not throw away any packing material until you account for all the parts.

To order a replacement part, always include the PART NUMBER. Refer to the "Replacement Parts" information inside the rear cover of this Manual.

KEY No.	HEATH Part No.	QTY.	DESCRIPTION
HARDWARE			
A1	250-1414	2	4-40 × 1/4" phillips screw
A2	250-1415	1	4-40 × 3/8" phillips screw
A3	250-1430	1	6-32 × 1/2" phillips screw
A4	252-2	4	4-40 nut
A5	254-9	4	#4 lockwasher
A6	254-1	9	#6 lockwasher
A7	255-735	8	Threaded spacer
A8	204-2734	1	Mounting bracket
CABLES – WIRE			
	134-1384	1	25-wire cable
	134-1385	1	Long 10-wire cable
	134-1386	1	Short 10-wire cable
	134-1387	1	2-wire cable
	134-1426	1	Jumper wire w/male pins
WIRED ASSEMBLIES			
	181-4946	1	Logic circuit board
	181-4947	1	Interface circuit board
	181-4948	1	Receiver circuit board
	181-4949	1	Transmitter

KEY No.	HEATH Part No.	QTY.	DESCRIPTION
MISCELLANEOUS			
B1	6-330-12	1	330 Ω, 5%, 1/4-watt (org-org-brn-gld) resistor
B2	150-75	1	6-volt battery charger
B3	142-733-1	1	Receiving antenna
B4	354-5	5	Cable tie
B5		1	Blue and white label
B6	490-5	1	Nut starter
B7	490-109	1	Alignment tool
B8	490-111	1	IC puller
B9		1	Crystal
B10		1	Transmit module
B11	260-1491	1	Shield
B12	390-2014-01	1	FCC label
			Manual (see page 1 for Part Number)
B13	390-2683	1	Antenna flag

INSTALLATION

Refer to Pictorial 1-1 (Illustration Booklet, Page 1) for the following steps.

( ) Unplug the battery charger (if it is installed) from the Robot and turn the POWER switch off.

( ) Remove the four screws from the head panel. Then remove the head panel from the Robot and set it and the screws aside.

( ) Unsnap the back panel from the Robot and set the panel aside.

Refer to Pictorial 1-2 (Illustration Booklet, Page 2) for the following steps.

( ) Remove the screws that hold the door closed. Set the screws aside and open the door.

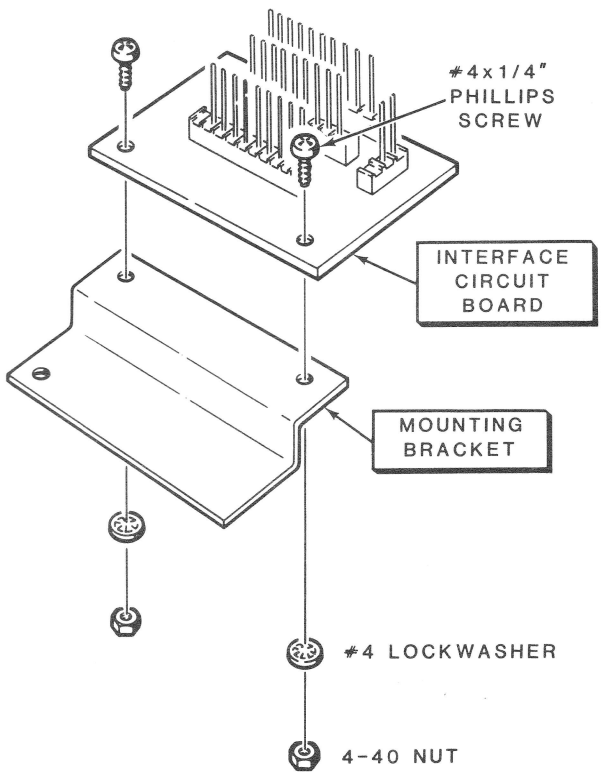
( ) Remove the hardware from the connector bracket and set the hardware aside. Allow the bracket to hang freely.

( ) Facing the back of the Robot, manually turn the Robot's head clockwise 90°. Remove the screw, nut and lockwasher from the base plate at A. Discard the screw, but set the lockwasher and nut aside for use later.

Refer to Pictorial 1-3 (Illustration Booklet, Page 2) for the following steps.

( ) Refer to Detail 1-3A and mount the interface circuit board to the mounting bracket with two #4 × 1/4" phillips screws, two #4 lockwashers, and two 4-40 nuts. Make sure that you mount the circuit board on the correct side of the mounting bracket flange as shown.

( ) Loosely mount the interface circuit board mounting bracket to the base plate at hole A with the 6-32 × 1/2" phillips screw supplied with the kit, and two #6 lockwashers. Use one of the #6 lockwashers and the nut you removed earlier from this location. Tighten the bracket just snug enough to hold it in place, then close the door to make sure it closes properly against the mounting bracket. When the mounting bracket is positioned properly so the door closes tightly, tighten the bracket screw securely.



Detail 1-3A

( ) Locate the red and orange 2-wire cable. Then refer to Detail 1-3B and insert the pins on the end of the red and orange wires into REMOTE plug holes 5 and 6. You can install the wires in either of the holes.

( ) Route the end of the red and orange 2-wire cable over the top of the center battery and up through the hole in the base. Plug the 3-hole connector over plug P304 on the interface circuit board. This connector is polarized to fit only one way.

( ) Remount the connector bracket to the base with the hardware you removed earlier. Refer back to Pictorial 1-2 if necessary.

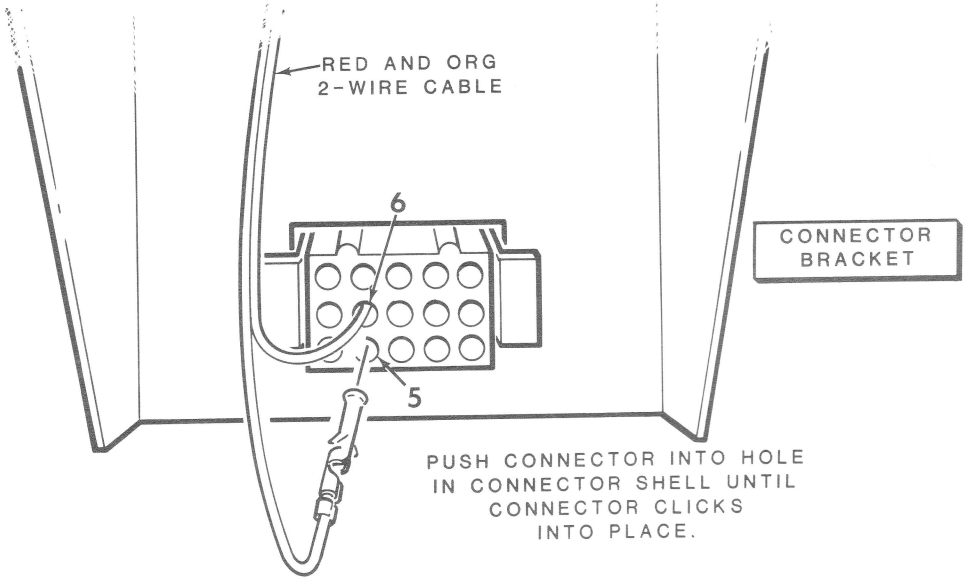
( ) Plug one connector of the long 10-wire cable over plug P301 on the interface circuit board. Both connectors are polarized to fit only one way. Route the other end of the cable up through the hole in the top and head plates. You will connect the free end of the 10-wire cable later.

( ) Refer to the inset drawing and install a cable tie around the 10-wire cable and the existing wire harness at each of the two indicated locations. Cut off the excess cable tie.

( ) Unplug I/O circuit board connectors P307 and P313. Reconnect connector P313 to plug P302 on the interface circuit board. Position the connector with the indicated wire color as shown.

( ) Locate the connector on the end of the short 10-wire cable without the polarizing pin. Connect this to I/O circuit board plug P313 with the slots facing down. Connect the other end of the cable to interface circuit board plug P303 with the polarizing pin as shown.

( ) Reconnect P307 to I/O circuit board plug P307 with the slots facing down. Make sure the connector goes over all of the plug pins and that you do not skip any.



Refer to Pictorial 1-4 (Illustration Booklet, Page 3) for the following steps.

( ) Mount a 4-40 × 3/8″ phillips screw, a #4 lockwasher, and a 4-40 nut at receiver board hole L from the bottom of the board as shown.

( ) Mount the receiving antenna to the screw at L with a #4 lockwasher, and a 4-40 nut. Position the antenna perpendicular to the edge of the circuit board.

( ) Refer to Detail 1-4A and remove the four nuts from the sonar receiver circuit board and set them aside.

( ) Refer to Detail 1-4A and mount the shield, the logic, and the receiver circuit boards over the sonar receive circuit board with the eight threaded spacers, lockwashers, and the four nuts you removed in the previous step. Position the shield and circuit boards as shown. NOTE: If your Robot has a terminal strip installed at the sonar receive circuit board location, bend the strip out to clear the logic circuit board when it is installed as shown. Also, bend the battery connectors close to the battery to prevent them from shorting to the circuit boards.

( ) Connect the brown, red, and orange wire cable connector coming from the logic circuit board to plug P201 on the receiver circuit board with the slots facing down.

( ) Connect the free end of the long 10-wire cable coming from interface circuit board plug P301 to logic circuit board plug P103. The connector is polarized to fit only one way.

( ) Remove the hardware from the display circuit board and set it aside.

( ) Unplug P1201 from the bottom of the display circuit board and reconnect it to logic circuit board plug P102 with the slots facing toward the receiver circuit board.

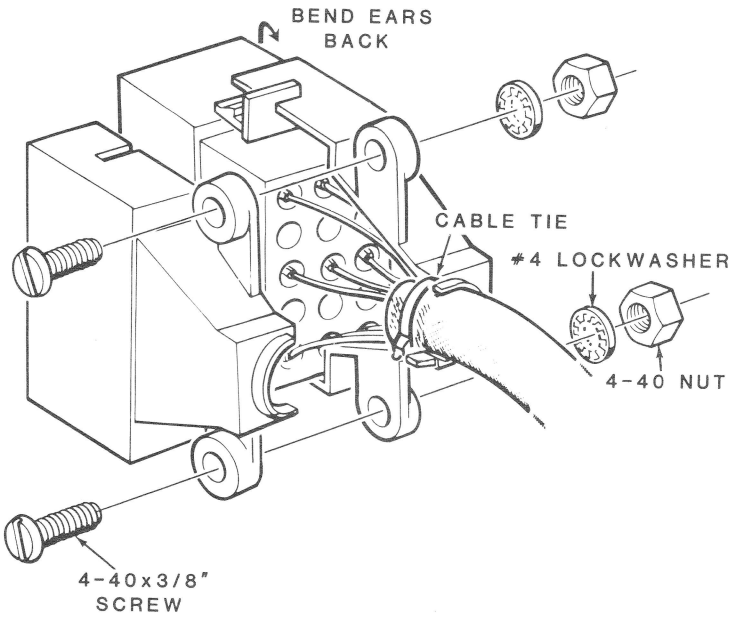
( ) Locate the connector on the end of the 25-wire flat cable without the polarizing plug. Insert this connector over display circuit board plug P1201 with the slots facing the keyboard end of the board. Connect the polarized connector on the flat cable to logic circuit board plug P101.

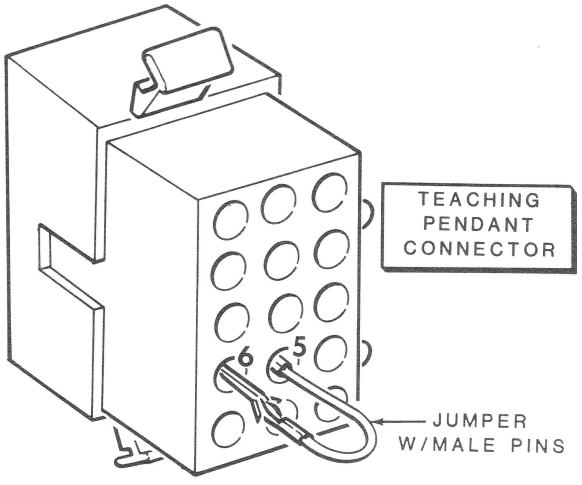
( ) Install two cable ties around the long 10-wire cable at the indicated locations and cut off the excess cable tie lengths.

( ) Reinstall the display circuit board with the hardware you removed earlier.

( ) Plug the crystal you received with your transmit module into the sockets at Y201 on the receiver circuit board.

( ) Manually rotate the Robot's head fully in both directions to make sure the wiring does not interfere with the movement. Redress the wiring as necessary. Also check all of the connectors you installed to make sure they have not been pulled loose.





PICTORIAL 1-5

Refer to Pictorial 1-5 for the following steps.

( ) Disassemble the connector on the end of the teaching pendant and set the hardware aside.

( ) Insert the male pins on the ends of the jumper wire w/male pins into teaching pendant connector holes 5 and 6. Make sure the pins lock into place.

( ) Reassemble the teaching pendant connector.

NOTE: If you have purchased the assembled Remote Control Accessory, perform the following numbered steps; otherwise, skip the steps and proceed to "Alignment".

Refer to Pictorial 1-6 (Illustration Booklet, Page 4) for the following steps.

1. ( ) Remove the six screws from the remote transmitter and remove the case top.

IMPORTANT: Do not attempt to open or modify the transmit module. If you do, you will be in violation of FCC regulations concerning this product.

2. ( ) Unplug the connector from the LED leads and install the transmit module onto plug P503. The plug is offset to fit only one way as shown in the inset drawing.

3. ( ) Reinstall the connector on the LED leads with the white-red wire connector over the shorter lead.

NOTE: Your ET/ETW-18-3 Remote Control has an "automatic steering centering" feature. This means that whenever you activate the switch to turn the front wheel on your Robot with the Robot stationary, the steering will automatically return to center when you release the switch. When the Robot is in motion, the steering will also always return to center automatically when you release the switch. If you wish to override this function so that the steering does not automatically return to center when the Robot is stationary, perform the next step; otherwise, skip the step.

4. ( ) Disconnect jumper J501 from the connector pin. Bend the wire back out of the way so it does not contact any other component. The automatic centering feature is now disabled.

5. ( ) Reinstall the transmitter's case top on the case bottom with the six screws you removed earlier.

This completes the "Installation." You will reinstall the Robot's panels later. Proceed to "Alignment."

ALIGNMENT

Before you begin to align the Remote Control Accessory, make sure of the following conditions to insure a proper alignment.

1. The Robot's head panel should be removed.

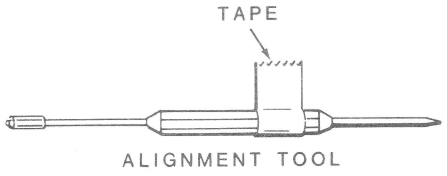
2. The complete ET/ETW-18-3 system should be installed and connected including crystal Y201 on the receiver circuit board.

3. The Robot's and transmitter's batteries should be fully charged.

4. Keep the Robot away from large metal objects such as walls, desks, cabinets; etc. during the alignment.

5. Keep out of the transmitter's signal path and as far as possible from the receiver's antenna during the alignment.

6. If you do not obtain the desired results during the alignment, turn the unit off and refer to the "In Case Of Difficulty" section on Page 25 of this Manual.



Detail 2-1A

Refer to Pictorial 2-1 (Illustration Booklet, Page 4) for the following steps.

( ) Refer to Detail 2-1A and place a piece of tape over the end of the alignment tool as shown. You will use this as an indicator to estimate where the coil tuning ranges are.

NOTE: You can operate the transmitter with the 6-volt battery charger plugged in.

( ) Fully extend the transmitter's antenna. Then turn both the transmitter and the Robot's power on.

( ) Hold the transmitter's antenna within a few feet of the Robot and observe LED D204 on the receiver circuit board. The LED should be lit. Slowly move the transmitter away from the Robot until the LED just goes out. NOTE: If you are too far away to see the LED, have someone else hold the transmitter while you observe the LED, or move close enough to where you can see the LED and begin to collapse the transmitter's antenna until the light goes out.

NOTE: Coils T201 and T202 are preset within approximately 1/4 turn for this Accessory. Always note the position of the alignment tool flag when you insert the tool into the slug before you begin to turn it. This will allow you to return it to that setting if necessary.

( ) With the transmitter at the location where the LED went out, use the alignment tool and carefully adjust the slug inside coil T201 in either direction (for no more than 1/4 turn) until the LED just lights. At this point, note the location of the alignment tool flag. Continue to rotate the slug until the light just goes out and note the location of the flag at this point. Set the coil slug at the center of these two extreme locations. NOTE: If T201 does not cause the LED to light, return the slug to its original position and adjust coil T202 in the same manner.

( ) Repeat the previous procedure and adjust receiver circuit board coil T202.

( ) Once coils T201 and T202 are adjusted, move the transmitter further away from the Robot until the LED once again goes out and readjust T201 and T202 as before. Repeat this procedure until there is less than 1/16 turn at the LED on and off locations for each coil.

( ) Turn the Robot and transmitter power off.

( ) If you have purchased the ET-18-3 Remote Control Accessory kit, sign and date the FCC label (#390-2013-11). Then remove the paper backing from the label and press the label onto the battery cover as shown. If you have purchased the assembled Accessory (ETW-18-3), remove the paper backing from the FCC label (#390-2014-01) and press the label onto the battery holder. Dicard the unused label.

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

FINAL ASSEMBLY

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

( ) Close the Robot's door and secure it with the two screws you removed earlier.

( ) Snap on the Robot's back panel.

( ) Remove the top 4-40 nut and #4 lockwasher from the receiver circuit board antenna and remove the antenna. Set the hardware aside.

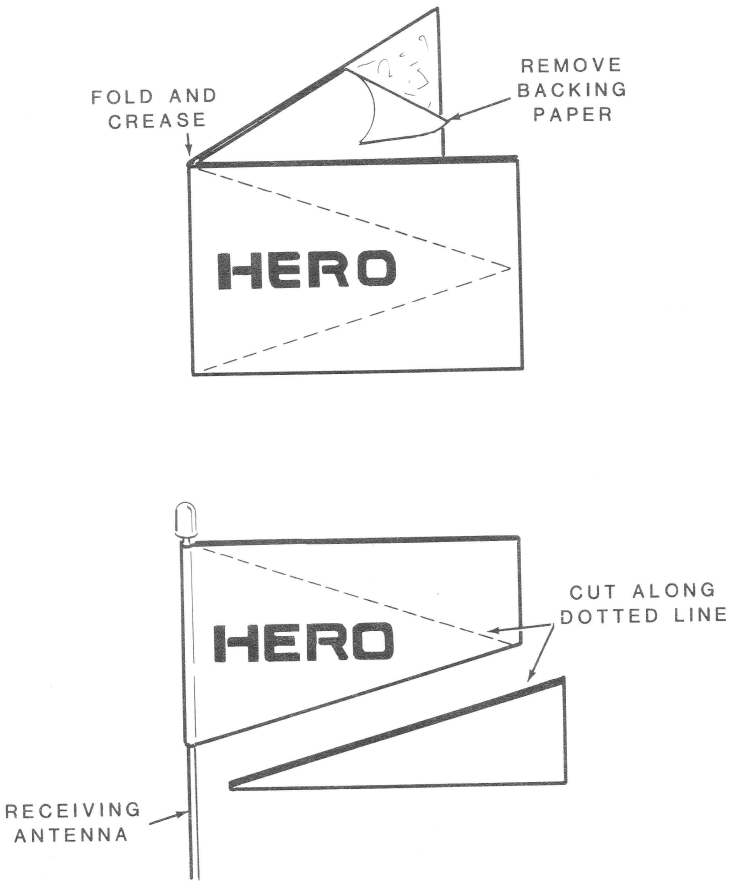
( ) Refer to Detail 2-2A and bend the antenna flag at its center and make a crease. Make sure the edges of the flag are even.

( ) Unfold the flag and remove the backing paper. Then place the top of the antenna along the flag crease and refold the flag over the top of the antenna. Cut the flag from the sheet along the dotted line.

( ) With the help of another person, position the robot head panel over the Robot and insert the bent end of the antenna through the fourth slot in the head panel as shown in the inset drawing. Then mount the antenna to reciever board screw L with the lockwasher and nut you removed earlier. Make sure to position the antenna on the circuit board as shown in the inset drawing.

( ) Lower the head panel onto the head plate and secure the head panel with the four screws you removed earlier.

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



Detail 2-2A

THEORY OF OPERATION

The Heathkit Model ET/ETW-18-3 Remote Control Accessory produces a pulse modulated, crystal-controlled, RF carrier. The coded modulation permits remote control of the Robot's hex key and teaching pendant functions when used with the receiver and logic circuits mounted inside the Robot.

Waveform A of Pictorial 3-1 (Illustration Booklet, Page 5) shows one frame of eight pulses that is repeated continuously every 21.71 msecs. Each pulse is .835 msecs wide. The time interval between the first pulse in one frame and the first pulse in the next frame is always 21.71 msecs and cannot be changed. This is called a "fixed frame rate." The time interval between any two sucessive pulses within a given frame can have one of two values; .835 msecs or 1.670 msecs. The .835 msec time interval gives the associated bit the binary value "0," while the 1.670 msec time interval indicates a value of binary "1." Waveform A shows that each bit has a binary value of "0" and the complete waveform has a binary value of "000000." Bit 6 through bit 0 each have the binary value 0 since the time intervals between the successive pulses are all .835 msecs wide. Waveform B has a binary value of 0000010 since bit 1 is 1.670 msecs wide. In this way, numerous binary codes can be transmitted to identify the various remote control functions.

The long space between the last pulse in a frame and the first pulse in the next frame is called the "sync pulse." This locks the decoder microprocessor (U107) in synchronization with the transmitted signal. The frame waveform modulates the RF carrier as shown. That is, the carrier is turned off during the .835 msec pulses but is on at all other times. This form of modulation reduces the possibility of the receiver circuit being triggered by interference, which could cause the Robot to operate erratically.

The receiver receives, amplifies, and detects this RF carrier to reproduce the pulse modulation waveform. In turn, this waveform is decoded by the microprocessor which then sets its output pins to actuate the corresponding control function in the Robot.

OPERATION

NOTE: The Remote Control transmitter performs the same functions as the Robot's teaching pendant and keyboard via an RF link. Before you begin to operate your Remote Control, you should become familiar with the Robot's teaching pendant and keyboard operation. The "Keyboard Operation" is explained in the ET-18 Technical Manual beginning on Page 10. The teaching pendant operation is explained in the ET-18 User's Guide on Page 21 beginning with "Executive Mode." The user's information beginning on Page 21 will familiarize you with the operation of the mechanical functions of the Robot using the teaching pendant. You should become familiar with the teaching pendant's functions before you continue with the Operation section in this Manual.

The teaching pendant overrides the transmitter teaching pendant whenever it is plugged into the Robot, therefore, you must unplug the teaching pendant whenver you wish to operate the Remote Control transmitter.

Refer to Pictorial 3-2 (Illustration Booklet, Page 6).

1. KEYBOARD — The remote transmitter performs the same functions as the Robot's keyboard and teaching pendant. The remote transmitter emits a tone whenever you press a keyboard pushbutton so that you know a key stroke has occurred. The six function switches do not cause a tone to be emitted when they are pressed. The remote transmitter has pushbuttons instead of the rotary and trigger switches like those used on the teaching pendant. The MOTION switch provides steering with the ARM/BODY switch in the BODY position and control of the arm functions in the ARM position. The function pushbuttons are labeled: F1 through F3 and R1 through R3. "F" designates "forward" and "R" designates "reverse." The higher the number designation, the faster the speed.

   The remaining keyboard pushbuttons are identical to the Robot's keyboard and operate the same. You can use either keyboard when you are in remote operation.

2. ON/OFF switch — Applies power to the transmitter circuits. The transmitter LED lights any time the power switch is turned on.

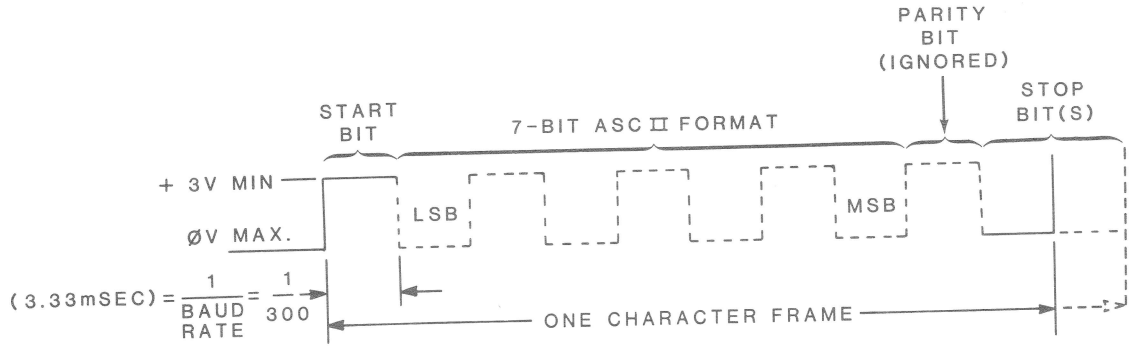
3 ARM/BODY switch — Selects the arm or body mode of operation.

4. MOTION switch — Controls the arm and head motion when the ARM/BODY switch is in the ARM position, or steers the Robot when the ARM/BODY switch is in the BODY position. The color-coded label helps coordinate the MOTION switch and FUNCTION pushbuttons.

5. CHARGER jack — Accepts the connector on the end of the battery charger supplied with the Remote Control Accessory. Refer to "Specifications" on Page 29 for the battery charge time.

6. RS-232C connector — Allows you to connect the transmitter to a computer for programming the Robot via the RF signal. The following sections are provided to better help you understand the RS-232C functions.

7. Telescoping Antenna — Transmits RF pulses to the remote control unit.



RS-232C INTERFACE

The waveform of each ASCII character received at hole 3 of socket P1 must have the following format:

The computer requirements are as follows:

300 BAUD.
A minimum voltage swing of +3 volts to 0 volts (±3V to ±25V are acceptable).
A start bit.
A 7-bit ASCII word.
A parity bit (the value is ignored, so it can be odd, even, or stick).
At least one stop bit.
It must acknowledge a high voltage level at socket 4 as a request to stop sending. NOTE: A 330 Ω pull-down resistor (supplied) may be required on the RTS line for some computers (e.g. Heath/Zenith H/Z-100 Series). If this is necessary, perform the following steps. Otherwise, skip the steps.

Refer to Pictorial 3-3 (Illustration Booklet, Page 6) for the following steps.

( ) Remove the six screws from the transmitter case and separate the case halves.

( ) Remove the four nuts from the transmitter circuit board.

( ) Unplug the connectors from P501, P502, and the LED, and remove the transmitter circuit board.

Refer to Pictorial 3-4 (Illustration Booklet, Page 7) for the following steps.

( ) Position the transmitter circuit board with the foil side facing up as shown.

( ) Refer to the inset drawing and prepare the leads of the 330 Ω, 1/4-watt, 5% (org-org-brn-gld) resistor as shown.

( ) Solder one lead of the prepared 330 Ω resistor to P502 pin 3 and the other lead to pin 5 of the transmitter circuit board. Make sure you do not solder bridge the foil pads.

( ) Refer back to Pictorial 3-3 and reinstall the transmitter circuit board connectors to the transmitter circuit board plugs as shown. Then mount the transmitter circuit board into the transmitter case with the four nuts you removed earlier.

( ) Mount the transmitter case halves together with the six screws you removed earlier.

RS-232C CONNECTOR WIRING (P1) INFORMATION

The RS-232C connector is wired as Data Communication Equipment (DCE). This wiring is used for the Heath H-89 Computer program using HDOS or CP/M. You may need to alter this wiring to fit your own computer.

RS-232C Connector
Socket 3 – Received data Socket 4 – Request to Send Socket 7 – Signal ground

RS-232C PROGRAMMING EXAMPLES

The following examples use a Heath H-89 computer under HDOS or CP/M to load a program into HERO 1 (ET-18) via the ET/ETW-18-3 Remote Control Accessory.

Refer to "Using HDOS" or "Using CP/M" to load a program into the Robot.

Using HDOS

You must have a bootable disk containing files PIP.ABS, LP.DVD, SET.ABS, and PIE.ABS for this example. (Assuming that LP.DVD is a renamed file such as LPH14.DVD, or LPH44.DVD.)

1. Set the line printer device driver (LP.DVD) to operate at 300 baud. Type the following:

```
SET LP: BAUD 300 ↵.
```

2. Dismount the disk and reboot it to retain this baud rate for future use. You may wish to rename this file using another disk and then reset LP.DVD to the desired baud rate for your printer.

3. Create a file containing the desired program to be loaded into HERO 1. This example is the SONAR TEST program which is explained on Page 57 of the ET-18 Technical Manual. Type the following:

```
>PIE SONAR.TST↵
R AA 0205 45 83 96 11 BD F6 4E BD F7 AD CE 20 00 09 26 FD↵
20 F0 R AD 0205, then simultaneously press CTRL E
```

NOTE: The number of lines and spaces used above are not critical. However, it does affect the execution speed and editing ease. Also, the ET/ETW-18-3 transmitter will only recognize the ASCII characters for numbers 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, and capital letters A, B, C, D, E, F, and R (reset) which correspond to the Robot's keyboard keys.

4. Connect the appropriate RS-232C cable (Heath cable #HCA-10) to the H-89 computer connector P1 (DCE 340-347) and to P1 of the ET/ETW-18-3 transmitter.

5. Turn on the Robot and transmitter's power. Then type:

```
>PIP↵
:P:LP:=SONAR.TST↵
```

The transmitter will beep for several seconds to indicate that it is receiving the ASCII signal from the H-89 computer. Then it will become silent and send approximately 30 bytes of the program to the Robot, whose display will indicate the bytes being received. The transmitter will beep again as it receives the remainder of the program from the H-89, then it will be silent as it sends the rest of the program to the Robot. The Robot's display should now be indicating the distance of the nearest object to its sonar sensors.

This completes the HDOS example. Refer to "Using The Remote Transmitter."

Using CP/M

1. Mount a bootable CP/M disk into drive A and a Wordstar disk into drive B of the computer.

2. Use a configure command to set the printer (LST) characteristics as follows. NOTE: You may wish to write down the present configuration before you change it in case you wish to return to it later.

   Baud Rate: 300.
   Port: 0E0H = 340Q.
   Printer Ready Signal Polarity: Low.
   Printer Ready Signal: RTS (pin 4).

3. Create a file to be named "SONAR.TST" on disk drive B using Wordstar, containing the desired program to be loaded into HERO 1. This example is the SONAR TEST program which is explained on Page 57 of the ET-18 Technical Manual. Type the following:

```
R AA 0205 45 83 96 11 BD F6 4E BD F7 AD CE 20 00 09 26 FD

20 F0 R AD 0205
```

NOTE: The number of lines and spaces used above are not critical. However, it does affect the execution speed and editing ease. Also, the ET/ETW-18-3 transmitter will only recognize the ASCII characters for numbers 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, and capital letters A, B, C, D, E, F, and R (reset) which correspond to the Robot's keyboard keys.

4. Connect the appropriate RS-232C cable (Heath cable #HCA-10) to the H-89 computer connector P1 (DCE 340-347) and to P1 of the ET/ETW-18-3 transmitter.

5. Turn on the Robot and transmitter's power. Then type:

```
A>PIP LST:=B: SONAR.TST ↵
```

The transmitter will beep for several seconds to indicate that it is receiving the ASCII signal from the H-89 computer. Then it will become silent and send approximately 30 bytes of the program to the Robot, whose display will indicate the bytes being received. The transmitter will beep again as it receives the remainder of the program from the H-89, then it will be silent as it sends the rest of the program to the Robot. The Robot's display should now be indicating the distance of the nearest object to its sonar sensors.

This completes the CP/M example.

NOTE: If your ET-18 Robot has the 1.3 or 1.U operating systems, it can be programmed to be silent when the RESET key is activated instead of saying "ready." To do this, enter the hexidecimal number AA at location OEDE. Use the following program: "R AE OEDE C AA R." You must re-enter this program each time the Robot is turned on.

USING THE REMOTE TRANSMITTER

Example

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

NOTE: You can make keyboard entries on either the remote or Robot keyboards. Be sure the teaching pendant is unplugged from the Robot.

1. Turn the Robot and transmitter on, extend the transmitter's antenna, and press keys **3** and **1** to initialize the Robot.

2. After the Robot is initialized, press key **4** to enter the Manual Mode.

3. Slide the ARM/BODY switch to the BODY position.

4. Push function pushbutton **F1** and the Robot will move slowly forward. Use the MOTION switch to steer left or right. As you hold the MOTION switch down, the turn will increase; release the switch and the turn will decrease. Release pushbutton **F1** and the Robot will stop. NOTE: If you have the automatic steering centering jumper on the transmitter circuit board enabled, the steering will automatically begin to center itself whenever you release the MOTION switch when the Robot is stationary.

5. Select pushbuttons **F2** and then **F3**, one at a time, and note that the speed increases.

6. Select pushbuttons **R1** through **R3** and the Robot will reverse at the three designated speeds.

7. Slide the ARM/BODY switch to the ARM position.

8. Press the HEAD pushbutton and use the MOTION switch to rotate the head left or right.

9. If you have the arm option installed on your Robot, select each of the five arm function switches and observe each operation as you press the MOTION switch. NOTE: If any of the arm motors are at the extreme limit of their travel, the MOTION switch will not produce a response. In that case, select the other switch direction and the Robot should respond within a second or two.

10. Press the RESET pushbutton to exit the Manual Mode.

11. Turn the Robot and transmitter power off.

Refer to the ET-18-1 Technical and/or User's Manuals to perform more complex operations with the Robot and Remote Control transmitter.

This completes the "Operation."

IN CASE OF DIFFICULTY

This part of the Manual will help you locate and correct difficulties that might occur with your Remote Control Accessory. This information is divided into two sections. The first section, "General," contains suggestions in the following areas:

A. Visual checks and inspection.

B. Precautions to observe when bench testing.

C. How to determine the area of the Remote Control in which the difficulty is located ("How To Troubleshoot Your Remote Control").

D. Locating and correcting both the cause and effect of a difficulty ("Repairing the Remote Control").

The second section consists of a "Troubleshooting Chart." This chart calls out specific problems that may occur and lists one or more conditions or components that could cause each difficulty. The resistor R numbers, capacitor C numbers, transitor Q numbers, diode D numbers, and integrated circuit U numbers are identified in this chart by the same numbers that are used on the Schematic Diagram. Circuit Board X-Ray Views (Illustration Booklet, Pages 8 and 9) are also provided to help you locate the components.

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

GENERAL

PRECAUTIONS FOR BENCH TESTING

1. Be cautious when you test solid-state circuits. Although transistors and integrated circuits have almost unlimited life when used properly, they are much more vulnerable to damage from excessive voltage or current than other circuit components.

2. Be sure you do not short any terminals to ground when you make voltage measurements. If the probe should slip, for example, and short out a bias or voltage supply, this could cause damage to one or more transistors, ICs, or diodes.

3. Do not remove transistors or any integrated circuits while the Remote Control Accessory is turned on, since this could damage it.

HOW TO TROUBLESHOOT YOUR REMOTE CONTROL ACCESSORY

If you know which area your trouble is in, apply the "Visual Checks" to that area.

You may also go directly to the "Troubleshooting Charts" to see if the difficulty you are having is listed in the "Problem" column. If your difficulty is listed there, check the "Possible Cause" column listed for that problem and apply the "Visual Checks" listed to the area of difficulty.

REPAIRING THE REMOTE CONTROL ACCESSORY

When you make repairs to the Remote Control, make sure you eliminate the cause as well as the effect of the difficulty. If, for example, you should find a damaged resistor, be sure you find out what caused the resistor to become damaged. If the cause is not eliminated, the replacement resistor may also become damaged when you put the Remote Control back into operation. For technical assistance, call: (616) 982-3296.

TROUBLESHOOTING CHART

TRANSMITTER

PROBLEM	POSSIBLE CAUSE
LED will not light.	1. Diode D1. 2. Resistor R501. 3. Switch SW1. 4. Battery weak.
Battery will not charge.	1. Diode D501. 2. Socket J1. 3. Charger is defective or not plugged in. 4. Battery defective.
Unit will not transmit.	1. Resistors R509, R511, and R512. 2. Transistor Q504. 3. Coils L501 and L502. 4. Battery weak. 5. Transmitter module. 6. IC U501. 7. Receiver inoperative.
RS-232C interface is inoperative.	1. Improper computer connections or baud rate. 2. Resistors R502 through R506. 3. Transistors Q501 and Q502. 4. Diode D503.
Operation is erratic.	1. Battery weak. 2. Resistor R507. 3. Diode D504. 4. Capacitor C509. 5. ICs U501 and U502. 6. Crystal Y501.

RECEIVER PROBLEM

Some of the keys will not operate.	1. Circuit associated diodes (D506-D512). 2. Jumper wires on keypad 3. Circuit board. 4. Keypad.
No tone present when hex keys are pressed.	1. Resistor R508. 2. Diode D505. 3. Transistor Q503. 4. Speaker A501.
ARM/BODY or LEFT/RIGHT functions do not operate.	1. Circuit associated switch (SW1 OR SW2). 2. Make sure all plugs are properly installed.

RECEIVER/LOGIC

Does receive an RF signal (D204 is not lit).	1. No power (check the robot battery). 2. T201 OR T202 misaligned. 3. Crystal Y201. 4. Receiver antenna shorted to mounting spacer. 5. Transmitter not operating. 6. Refer to the "Receiver" Circuit Description.
Unit was operating, but stopped.	1. Temporary loss of RF signal due to distance or obstacles. 2. Press the Robot's "Reset" key to reset IC U107. 3. Transmitter or Robot batteries are weak.
Original keyboard is inoperative.	1. ICs U101 and U102. 2. Wiring harness not connected properly.
Unit is inoperative (D204 not lit).	1. Transistors Q105 through Q107 and associated components. 2. IC U107. 3. Crystal Y101. 4. Batteries are weak. 5. Refer to the Circuit Description.
Original teaching pendant is inoperative.	1. Wiring harness improperly installed. 2. Jumper wire is missing from teaching pendant plug. 3. IC U108.
Column of key functions are inoperative.	1. Circuit transistors Q101 through Q103 and their associated components. 2. ICs U101 through U106.

SPECIFICATIONS

TRANSMITTER

RF Power	100 mW (approximately).
RF Carrier Frequency	75.430 MHz, or 75-670 MHz, or 75.879 mHz (only one frequency is supplied with the ET/ETW-18-3).
Modulation	Pulse width modulation.
Temp. Range	0-50 C° (32 – 122 F°).
Current Drain	125 mA typical.
Power Source	6V, 1.2 AH sealed, rechargeable battery
Charge Time	12 hrs. (typical).
Dimensions	8-1/2″ W × 2-1/2″ H × 5-1/2″ D. (21.6 × 6.4 × 14.0 cm).
Controls	26 switches to duplicate all hex keyboard and teaching pendant functions.
Weight	1 lb. 14 oz. (841 grams).

RECEIVER

Type	AM superhetrodyne.
IF Frequency	453 kHz.
Sensitivity	35 uV or less.
Current Drain (typical)	10 mA with transmitter OFF; 120 mA with transmitter on.
Supply	+ 5 VDC from Robot.

RS-232C INTERFACE

Receive	300 baud
Transmit	5 bytes/second (average).

INSTRUMENT ALIGNMENT

Equipment needed:

RF generator
100 MHz counter

Refer to Pictorial 4-1 (Illustration Booklet, Page 7) for the following steps.

( ) Connect the RF generator's output cable to the counter's input. Then set the RF generator's output for the appropriate channel frequency (75.430, 75.670, or 75.879 MHz) and the modulation for 100% AM at 400 or 1000 Hz.

( ) Turn the RF generator's output level to minimum.

( ) Connect a cable to the RF generator's output and drape the free end of the cable to within a few inches of the Robot's receiver antenna.

NOTE: You may also remove the receiver antenna and connect the antenna input to the RF generator's output cable through a .001 uF capacitor.

( ) Turn the Robot's power switch to on. Turn the RF generator's output level up slowly until receiver board LED D204 just lights dimly.

( ) Use the plastic alignment tool and adjust receiver circuit board coils L201 and L202 to the center of the tuning range that causes the LED to light at its brightest level. Repeat this process several times. Reduce the RF generator's output each time until the tuning range of each coil is less than 1/16 of a turn.

This completes the "Instrument Alignment."

CIRCUIT DESCRIPTION

Refer to the Schematic Diagram (fold-in) and the Block Diagram, (Illustration Booklet, Page 8) as you read the following "Circuit Description."

TRANSMITTER

POWER SUPPLY

Power is supplied by a 6VDC rechargeable battery. Diode D501 limits the charger voltage and current to prolong the battery life. When power switch SW1 is turned on, current flows thru this switch and lights the Power On LED, D1. Resistor R501 limits the current thru D1. Bypass capacitor C501 bypasses any RF which helps stabilize the voltage regulator IC U501. Since the battery voltage will vary according to its state of charge, voltage regulator U501 is used to maintain a constant 5VDC output necessary for proper operation of the microprocessor U502. Filter capacitor C502 reduces the ripple on the 5VDC supply caused by the varying load currents of the circuitry.

MICROPROCESSOR

The microprocessor IC U502 has several functions. It scans the keyboard to determine if any keys have been pressed; it generates a tone whenever a hex key is pressed, or while it is receiving information from a computer. U502 also determines the position of ARM/BODY switch SW2 and LEFT/RIGHT switch SW3. In addition, the microprocessor sends an appropriate code by turning the transmitter module on and off.

Keyboard Scanning — The microprocessor sequencially outputs a low voltage on pins 8 through 13 while it monitors the voltages on pins 3 through 6. If a key is pressed, it will cause a particular row to be shorted to its associated column in this keyboard matrix. For example, when the "Reset" key is pressed, it shorts the column connected to microprocessor pin 6 to the row connected to pin 13. When the microprocessor outputs a low voltage on pin 13, pin 6 will be pulled low through diode D512. In this manner, the microprocessor can determine exactly which key is being pressed.

Switch Position Sensing — By monitoring the voltages on pins 17, 18, and 19 , the microprocessor can determine which position the ARM/BODY and LEFT/RIGHT switches are in. If the LEFT/RIGHT switch was in the LEFT position, pin 18 would be pulled low. Also, the microprocessor senses the voltage at pin 26 to see if the automatic wheel straight mode is operating when using the teaching pendant contols.

Tone Generation — This tone is used for audible feedback. If a key being pressed is not one of the teaching pendant keys, pin 33 will be toggled high-to-low at a 600hz rate. This signal is DC coupled thru resistor R508 to transistor Q503 which

amplifies the signal and applies it to speaker A501. Diode D505 clips positive-going voltage spikes generated by the speaker to minimize the noise on the 5VDC supply. In the same manner, the microprocessor generates a tone when information from a computer is being sent to it on pin 38 via transistor Q502.

Computer Interface — This interface allows programs stored in a computer to be loaded into the Robot. The ASCII signal sent at 300 baud from a computer is applied to pin 3 of the RS232C connector P1. This signal is coupled to transistor Q501 thru resistor R505. Q501 inverts this signal and applies it to pin 38 of the microprocessor. When the microprocessor has received approximately 30 ASCII characters, pin 15 will go low. This causes Q501 to be biased on through resistor R503 and pin 4 of P1 will go high which signals the computer to stop sending ASCII information. Now the microprocessor transmits the information received from the computer in its own format to the receiver installed in the Robot. When all of the stored information has been sent, the microprocessor sets pin 15 high which turns Q501 off and signals the computer that the microprocessor is ready to receive more ASCII information. When the computer has finished sending the program, the microprocessor will wait a few seconds and transmit the remainder of this stored program. The microprocessor will recognize the ASCII code for the hexidecimal numbers "0 through F" and "R" (Reset) only.

Code Generation and Transmission — After the microprocessor has scanned the keys and switch positions, it determines the proper code to be transmitted. It then begins to toggle pin 37 high and low at a prescribed rate. This signal is serially coded and causes transistor Q504 to be biased off and on through resistor R511 at the same rate. When Q504 is turned on, current flows through inductor L502 causing the transmitter module to emit an RF signal via the antenna. When Q504 is off, no RF signal is transmitted. In this manner, the code is relayed to the receiver mounted in the Robot.

RECEIVER

The transmitted RF signal is picked up at the antenna and fed to the tuned circuit of transformer T201 and capacitor C201. Diode D201 is used to limit strong signals and prevent overloading of the RF stage. From the secondary of T201, the signal is coupled to the base of RF amplifier transistor Q201. The amplified signal is applied to the tuned circuit comprised of C202 and T202, which are also tuned to the transmitter signal frequency. T202 is tapped to provide an impedance match to the collector of Q201. From the secondary of T202, the signal is coupled to the emitter of autodyne converter transistor Q202. Regenerative feedback through the receiver crystal Y201 causes the autodyne converter circuit to oscillate at the crystal's second harmonic frequency. The input signal and the oscillator signal beat together in transistor Q203 to produce a 453kHz difference signal that is passed into coil L201.

From L201, the 453kHz signal passes through resistor R205 to the first ceramic IF filter Y202. Capacitor C208 tunes with L201 near the crystal oscillator frequency. Each ceramic filter is tuned to and passes the 453kHz IF frequency and attenuates unwanted signals. The IF signal is coupled through Y202, Y203, Y204, and resistor R213 to the base of first IF amplifier transistor Q203. The amplified IF signal is further amplified by transistor Q204 and coupled through capacitor C213 to the base of power detector transistor Q205. Diode D202 is forward biased by resistor R218 so that .5 VDC is applied to the base of transistor Q205 through coil L203, which will hold Q205 at cut off. Since Q205 requires about .6 volt at its base to conduct, the additional .1 volt is supplied by the positive portion of the IF signal. Thus, Q205 conducts only on the positive portion of the IF signal.

As mentioned in the transmitter circuit description, the RF signal is coded by turning off the transmitter at certain intervals. This gap in the RF transmission also stops the IF carrier. At this time, Q205 does not conduct and causes its collector voltage to go high. This produces a positive pulse from Q205 that is equivalent to the pulse at pin 37 of the microprocessor IC U502 in the transmitter. In this way, the serial pulse code generated by the microprocessor is recovered by the receiver.

Capacitor C215 bypasses the IF frequency and leaves a train of audio frequency pulses that are coupled through diode D203, resistor R223, and capacitor C218 to the base of pulse amplifier transistor Q206. Diode D203 and resistors R222 and R224 eliminate noise pulses under strong signal conditions, and intergrator network R223 and C219 prevent noise from interfering under weak signal conditions.

An automatic gain control (AGC) circuit that consists of resistors R202, R203, R214, and R219, and capacitors C205 and C212. This feeds back part of the transistor Q205 collector voltage to the base circuits of transistors Q201 and Q203. The stronger the receiver signal, the more Q205 conducts and lowers the voltage of its collector. This, in turn, lowers the bias voltage of Q201 and Q203 reducing their gain. This AGC action prevents the IF amplifier and detector circuits from overloading and producing improper pulses when strong signals are being received.

Pulse amplifier transistors Q206, Q207, and Q208 further increase the amplitude of the pulses from Q205. This amplified pulse train is coupled to the logic circuitry through connector P201. It is also coupled to transistor Q209 through resistor R233. These positive-going pulses cause transistor Q233 to conduct which forward biases LED D204 causing it to light. Thus, D204 lights when the RF signal is received.

LOGIC CIRCUIT

The pulses from the receiver are coupled through resistor R122 causing transistor Q105 to conduct charging capacitor C121. Current then flows through resistor R123 turning on the Darlington transistor Q106. This turns on the pass transistor Q107, causing its collector voltage to go high and supply current to ICs U103 through U108. Capacitor C111 charges through resistor R115 and the logic microprocessor U107 will begin to function when the voltage at its reset pin (pin 39) becomes high enough.

The microprocessor first switches pin 26 high to keep transistors Q106 and Q107 turned on in case the pulse train from the receiver is momentarily interrupted. Next, the microprocessor switches all of its output pins connected to U103 through U106, U108, and Q104 to the low state so as not to simulate any key closures or teaching pendant functions. Now the microprocessor monitor the pulse train from the receiver at pin 38, deciphers the coded information, and switches its corresponding pin(s) to the high state. A new frame of information is received every 22 msecs., thus, the microprocessor changes the state of its output pins at this 22msec. rate.

The pins of the microprocessor IC U107 are connected to the two input NAND gates of ICs U103 through U106, and represent the hexidecimal (0 through F) numbered keys. Transistors Q101 through Q103 are used to invert the scan lines generated by the Robots microprocessor. The two input AND gate ICs U101 and U102 are needed to couple key closures from the keys on the Robot's display PCB and simulated key closures from the remote contol microprocessor IC U107 back to the Robot's microprocessor. The following example will help explain how this logic works.

If you press the "2" key on the ET-18-3 transmitter, the transmitter sends the appropriate RF coded signal to the receiver. The receiver demodulates this RF signal and the resulting pulse train is coupled to pin 38 of the microprocessor IC U107. U107 will recognize this coded pulse train as the key "2" and switch its pin 11 to the high output state (5VDC). This voltage is applied directly to the input pin 4 of NAND gate IC U104. When the scan line (pin 6 of connector P102) goes low (0VDC), transistor Q102 is biased off causing its collector voltage to go high. This voltage is applied directly to input pin 5 of U104. Since both input pins of this NAND gate are now high, its output pin (pin 6) will switch to a low state. This low voltage is applied to the input pin 1 of the AND gate in U102 causing its output pin to go low and pull pin 16 of P102 low. The Robot's microprocessor recognizes that key "2" is being pressed when it outputs a low voltage to pin 6 of P102 and receives a low voltage on pin 16 of P102. The same result happens when key "2" is

pressed on the Robot's display PCB. This is due to the low scan line voltage from pin 6 of P102 being coupled through key "2" back to input pin 2 of U102 via pin 16 of P101. This also causes the output pin 3 of U102 to go low pulling pin 16 of P102 low. The other hex key closures are detected in the same manner.

The "RESET" key detection involves no scan lines. When pin 23 of U107 goes high to forward bias Q104, the collector of Q104 pulls pins 10 and 11 of P102 low to reset the Robot's microprocessor. The RESET key on the display PCB resets the Robot's microprocessor by pulling pins 10 and 11 low through diode D103 and also resets the logic PCB microprocessor (U107) by pulling its pin 39 low through diode D102.

The ET/ETW-18-3 also duplicates the teaching pendant functions. The microprocessor IC U107 recognizes certain coded pulse trains as teaching pendant instructions. It sets the states of pins 27 through 33, which are transferred to the teaching pendant port 313 of the I/O circuit board through the tri-state buffer IC U108. Thus, the original teaching pendant is duplicated. A jumper wire added to the original teaching pendant's socket causes pin 10 of P103 to go high when it is connected to the Robot. This applies 5VDC to pins 1 and 19 of IC U108 setting the output pins of U108 to the high impedance state so as not to interfere with the functioning of the original teaching pendant.

When the transmitter is turned off, the coded pulse train will no longer be present at pin 38 of U107. The microprocessor will begin timing how long these pulses have been missing. After approximately 6 seconds, the microprocessor will set its pin 26 low. Capacitor C121 will discharge turning off transistors Q106 and Q107. Thus, no voltage supply will exist for IC's U103 through U108. They will be turned off. This conserves the Robot's battery power when the ET/ETW-8-3 is not being used. The receiver is turned on whenever the robot is on.

SEMICONDUCTOR IDENTIFICATION

This section is divided into two parts; Component Number Index and Part Number Index. The first section provides a cross-reference between semiconductor component numbers and their respective Part Numbers. The component numbers are listed in numerical order. The second section provides a lead configuration detail (basing diagram) for each semiconductor Part Number. The Part Numbers in the second section are also listed in numerical order.

COMPONENT NUMBER INDEX

DIODES

CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER
D1	412-658
D101	56-56
D102	56-56
D103	56-56
D201	56-84
D202	56-84
D203	56-84
D204	412-640
D501	57-65
D502	NOT USED
D503 – D512	56-56

TRANSISTORS

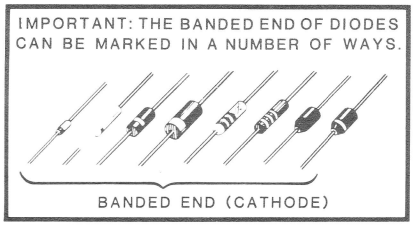
CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER
Q101 – Q105	417-801
Q106	417-881
Q107	417-819
Q201	417-887
Q202	417-293
Q203	417-801
Q204	417-235
Q205	417-801
Q206	417-801
Q207	417-235
Q208	417-801
Q209	417-801
Q501	417-235
Q502	417-801
Q503	417-801
Q504	417-23

INTEGRATED CIRCUITS

CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER
U101	443-780
U102	443-780
U103 – U106	443-1007
U107	444-250
U108	443-791
U501	442-716
U502	444-250

PART NUMBER INDEX

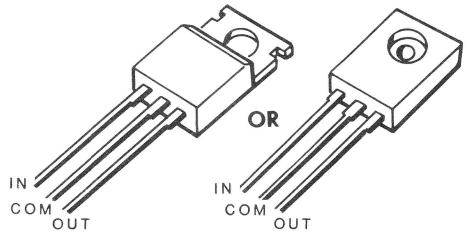
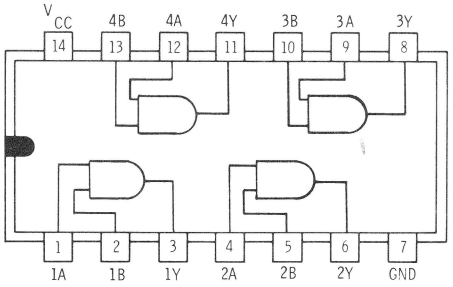
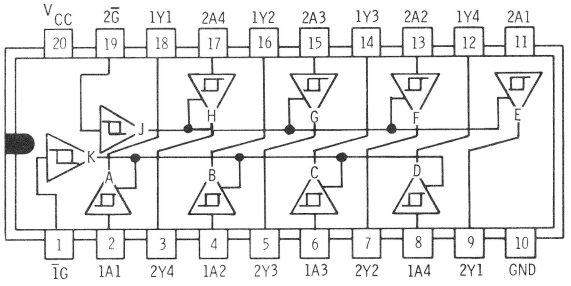
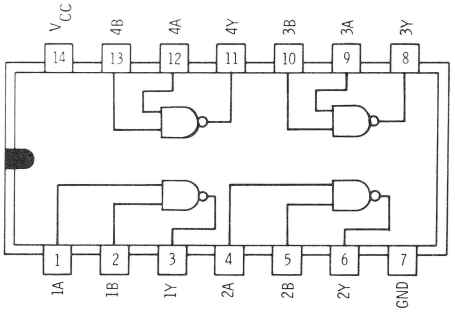
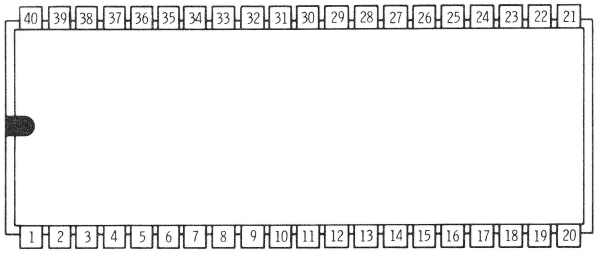
DIODES

CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION (TOP VIEW)
D101 – D103 D503 – D512	56-56	1N4149	
D201 – D203	56-84	1N4148	
D501	57-65	1N4002	
D1	412-658	Red, 2.5 v, 20 mA	
D204	412-640	Red, 2.5 v, 20 mA, LST-5053	

TRANSISTORS

CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION (TOP VIEW)
Q204, Q207, Q501, Q504	417-235	2N4121	
Q202	417-293	2N5770	
Q203, Q205, Q206, Q208, Q209, Q502, Q503, Q101 – Q105	417-801	MPSA20	
Q106	417-881	MPSA13	
Q201	417-887	MPSH10	
Q107	417-819	MJE171	

INTEGRATED CIRCUITS

CIRCUIT COMPONENT NUMBER	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION (TOP VIEW)
U501	442-716	LM330	
U101, U102	443-780	74LS08	
U108	443-791	74LS244	
U103 – U106	443-1007	74LS26	
U107, U502	444-250	Programmed microprocessor available only from Heath Company.	

REPLACEMENT PARTS LIST

LOGIC CIRCUIT BOARD

RESISTORS

NOTE: All resistors are 1/4-watt, 5%.

CIRCUIT Comp. No.	HEATH Part No.	DESCRIPTION
R101	6-222-12	2200 Ω
R102	6-222-12	2200 Ω
R103	6-222-12	2200 Ω
R104	6-222-12	2200 Ω
R105	6-222-12	2200 Ω
R106	6-273-12	27 kΩ
R107	6-103-12	10 kΩ
R108	6-222-12	2200 Ω
R109	6-273-12	27 kΩ
R110	Not used	
R111	6-103-12	10 kΩ
R112	6-222-12	2200 Ω
R113	6-273-12	27 kΩ
R114	6-103-12	10 kΩ
R115	6-103-12	10 kΩ
R116	6-222-12	2200 Ω
R117	6-222-12	2200 Ω
R118	6-103-12	10 kΩ
R119	6-273-12	27 kΩ
R120	Not used	
R121	6-273-12	27 kΩ
R122	6-103-12	10 kΩ
R123	6-273-12	27 kΩ
R124	6-273-12	27 kΩ
R125	6-221-12	220 Ω
R126	6-102-12	1000 Ω
R127	6-473-12	47 kΩ

CAPACITORS

CIRCUIT Comp. No.	HEATH Part No.	DESCRIPTION
C101	21-140	.001 µF ceramic
C102	21-140	.001 µF ceramic
C103	21-140	.001 µF ceramic
C104	21-140	.001 µF ceramic
C105	21-140	.001 µF ceramic
C106	21-140	.001 µF ceramic
C107	21-140	.001 µF ceramic
C108	25-930	2.2 µF electrolytic
C109	25-838	3.3 µF tantalum electrolytic
C110	Not used	
C111	25-917	10 µF electrolytic
C112 – C119	21-75	100 pF ceramic
C120	Not used	
C121	21-762	.1 µF glass ceramic
C122	25-917	10 µF electrolytic
C123	25-918	100 µF electrolytic
C124 – C128	21-769	.01 µF glass ceramic

CRYSTAL

Y101	404-536	4 MHz crystal

DIODES – TRANSISTORS – INTEGRATED CIRCUITS

See "Semiconductor Identification."

RECEIVER CIRCUIT BOARD

RESISTORS

NOTE: All resistors are 1/4-watt, 5%.

CIRCUIT Comp. No.	HEATH Part No.	DESCRIPTION
R201	6-102-12	1000 Ω
R202	6-183-12	18 kΩ
R203	6-183-12	18 kΩ
R204	6-272-12	2700 Ω
R205	6-101-12	100 Ω
R206	6-562-12	5600 Ω
R207	6-821-12	820 Ω
R208	6-682-12	6800 Ω
R209	6-151-12	150 Ω
R210	Not used	
R211	6-272-12	2700 Ω
R212	6-272-12	2700 Ω
R213	6-102-12	1000 Ω
R214	6-272-12	2700 Ω
R215	6-222-12	2200 Ω
R216	6-222-12	2200 Ω
R217	6-222-12	2200 Ω
R218	6-153-12	15 kΩ
R219	6-103-12	10 kΩ
R220	Not used	
R221	6-102-12	1000 Ω
R222	6-183-12	18 kΩ
R223	6-103-12	10 kΩ
R224	6-273-12	27 kΩ
R225	6-223-12	22 kΩ
R226	6-683-12	68 kΩ
R227	6-101-12	100 Ω
R228	6-682-12	6800 Ω
R229	6-333-12	33 kΩ
R230	Not used	
R231	6-184-12	180 kΩ
R232	6-151-12	150 Ω
R233	6-333-12	33 kΩ

CAPACITORS

CIRCUIT Comp. No.	HEATH Part No.	DESCRIPTION
C201	21-743	27 pF ceramic
C202	21-743	27 pF ceramic
C203	27-129	.047 μF Mylar
C204	27-129	.047 μF Mylar
C205	27-129	.047 μF Mylar
C206	27-129	.047 μF Mylar
C207	20-110	75 pF mica
C208	20-159	39 pF mica
C209	27-129	.047 μF Mylar
C210	Not used	
C211	27-129	.047 μF Mylar
C212	25-924	2.2 μF electrolytic
C213	20-105	180 pF mica
C214	27-129	.047 μF Mylar
C215	27-129	.047 μF Mylar
C216	27-129	.047 μF Mylar
C217	25-918	100 μF electrolytic
C218	25-924	2.2 μF electrolytic
C219	21-27	.005 μF ceramic
C220	Not used	
C221	21-784	.001 μF ceramic

INDUCTORS – CHOKE

L201	40-319	2.2 μH inductor
L202	45-80	1 mH choke
L203	45-80	1 mH choke
T201	40-917	.217 μH inductor
T202	40-918	.232 μH inductor

FILTER

Y201	Receive crystal	(3 optional frequencies)
Y202	404-630	455 kHz ceramic filter
Y203	404-630	455 kHz ceramic filter
Y204	404-630	455 kHz ceramic filter

DIODES – TRANSISTORS – INTEGRATED CIRCUITS

See "Semiconductor Identification."

TRANSMITTER CIRCUIT BOARD

CIRCUIT Comp. No.	HEATH Part No.	DESCRIPTION
RESISTORS		
NOTE: All resistors are 1/4-watt, 5%.		
R501	6-271-12	270 Ω
R502	6-473-12	47 kΩ
R503	6-103-12	10 kΩ
R504	6-472-12	4700 Ω
R505	6-223-12	22 kΩ
R506	6-103-12	10 kΩ
R507	6-103-12	10 kΩ
R508	6-472-12	4700 Ω
R509	6-473-12	47 kΩ
R510	Not used	
R511	6-103-12	10 kΩ
R512	6-103-12	10 kΩ
CAPACITORS		
C501	21-762	.1 µF (104) glass ceramic
C502	25-919	150 µF electrolytic
C503 – C507	21-75	100 pF ceramic
C508	25-838	3.3 µF tantalum electrolytic
C509	25-917	10 µF electrolytic
C510	Not used	
C511 – C514	21-75	100 pF ceramic
C515	21-762	.1 µF (104) glass ceramic
CHOKE – CRYSTAL		
L501	45-39	4.65 µH choke
L502	45-39	4.65 µH choke
Y501	404-536	4 MHz crystal
DIODES – TRANSISTORS – INTEGRATED CIRCUITS		
See "Semiconductor Identification."		

CASE

CIRCUIT Comp. No.	HEATH Part No.	DESCRIPTION
MISCELLANEOUS		
	418-44	6 volt battery
	181-4950	Wired keypad
SW1	60-78	Slide switch
SW2	60-78	Slide switch
SW3	61-44	Rocker switch
	92-810	Case top
	92-811	Case bottom
	142-732	Antenna
		Transmit modules, one of the following:
	291-35	375.43 MHz
	291-36	375.67 MHz
	291-37	375.87 MHz

595-3162