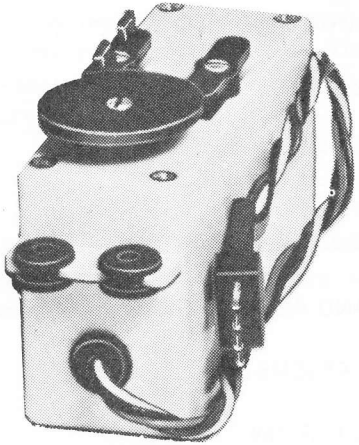
Assembly and Operation

of the

HEATHKIT

DIGITAL PROPORTIONAL SERVO

MODEL GDA-19-4



HEATH COMPANY
Benton Harbor, Michigan 49022

PARTS LIST

The key numbers correspond to the numbers in the Parts Pictorial. Disregard any numbers that are not on the Parts List when more than one number is on any package or part in this kit.

To order replacement parts, refer to the Replacement Parts Price List and use the Parts Order Form furnished with this kit.

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION
RESISTORS			
1/4 Watt			
1	1-20-12	1	33 Ω (orange-orange-black)
	1-51-12	2	47 Ω (yellow-violet-black)
	1-17-12	1	220 Ω (red-red-brown)
	1-24-12	1	820 Ω (gray-red-brown)
	1-3-12	1	1200 Ω (brown-red-red)
	1-4-12	3	2200 Ω (red-red-red)
	1-6-12	1	3300 Ω (orange-orange-red)
	1-8-12	3	4700 Ω (yellow-violet-red)
	1-28-12	1	8200 Ω (gray-red-red)
	1-9-12	1	10 kΩ (brown-black-orange)
	1-45-12	2	22 kΩ (red-red-orange)
	1-11-12	2	47 kΩ (yellow-violet-orange)
	1-50-12	1	11 MΩ (brown-brown-blue)

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION
CAPACITORS			
2	21-6	1	27 pF disc
	21-140	1	.001 μF disc
	21-141	1	.0033 μF disc
	21-94	3	.05 μF disc
3	25-197	3	1.0 μF electrolytic
4	26-121	1	2-section variable

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION

TRANSISTORS

NOTE: Transistors are marked for identification in one of the following four ways:

1. Part number.
2. Transistor type number.
3. Part number and transistor type number.
4. Part number with a transistor type number other than the one listed.

5	417-91	2	2N5232A/2N3391A
	417-200	5	X29A826
6	117-6	1	Transistor pair
	Consisting of:		
		1	2N2430
		1	2N2431

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION

WIRE-SLEEVING

	344-90	1	Black wire
	344-92	1	Red wire
	344-95	1	Green wire
	344-99	1	White wire
	344-110	1	Special flex wire (gray)
	346-1	1	Small sleeving
	346-20	1	Large sleeving

GENERAL

7	73-59	4	Large rubber grommet
	73-53	1	Small rubber grommet
	85-305	1	Circuit board
8	420-56	1	Motor
9	432-104	1	4-pin male connector
	391-34	1	Blue and white label
	597-260	1	Parts order form
	597-308	1	Kit Builders Guide
		1	Manual (See front cover for part number.)
			Solder

HARDWARE

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION
10	250-355	3	2-32 x 3/16" sheet metal screw
11	250-353	4	2-56 x 7/16" screw
12	250-352	2	2-56 x 11/16" screw
13	250-354	2	3-56 x 1/8" screw
14	250-82	4	#4 x 1/2" wood screw
15	452-19	3	Gear pin

MOLDED NYLON PARTS

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION
16	266-111	1	Linear output arm (with tabs)
17	266-100	1	Linear output arm (without tabs)

Molded Nylon Parts (cont'd.)

KEY No.	PART No.	PARTS Per Kit	DESCRIPTION
18	266-102	1	Rotary output arm
19	266-101	1	Rotary output wheel
20	92-41	1	Case top section
21	451-59	1	Right rack gear
22	451-54	1	Left rack gear
23	266-99	1	Rack gear guide
24	451-53	1	Capacitor drive gear
25	451-52	1	Rack drive gear
26	451-51	1	Idler gear
27	451-50	1	Motor coupling gear
28	92-42	1	Case center section
29	262-14	1	Pin
30	92-43	1	Case bottom section

TEST AND ADJUSTMENTS

CENTERING

The following adjustments are only for the Servo. Do not attempt these adjustments unless the transmitter has been completely adjusted with a Servo according to the instructions.

Picking up and touching the Servo in the following steps can cause the Servo motor to hunt. This is normal due to "hum" pickup from your hand. After an adjustment, the Servo should be set down on the work surface to be sure the correct amount of adjustment has been made. Make all adjustments with a screwdriver or alignment tool.

If the Servo does not operate as described, refer to the "In Case of Difficulty" section on Page 32.

Refer to Figure 3 (fold-out from Page 20) for the following steps.

( ) Connect the Servo to channel #1 of the receiver.

( ) Turn the transmitter on. Be sure the channel #1 trim tab is in its center position.

( ) Turn the receiver battery switch on. The Servo motor may start to run and then stop. This is normal.

( ) Move the channel #1 stick in one direction and then the other. The Servo arms should move, stop, and reverse according to the stick position.

( ) Release the stick.

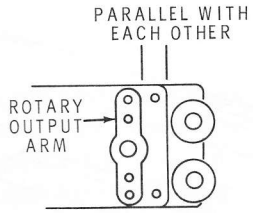


Figure 4

NOTE: If the rotary output arm is now parallel to the end of the Servo case, disregard the next four steps, and turn the units off. See Figure 4.

( ) 1. Remove the case bottom section by removing the two 2-56 x 11/16" screws.

( ) 2. Adjust (one or both) the trimmer(s) on the rear of the variable capacitor until the rotary output arm is perfectly parallel to the end of the Servo case. See Figure 5.

( ) 3. Turn the receiver and the transmitter off.

( ) 4. Mount the case bottom section on the case center section of the Servo with 2-56 x 11/16" screws. Be sure that no wires are pinched between the two sections of the case and that the rubber grommet is positioned properly.

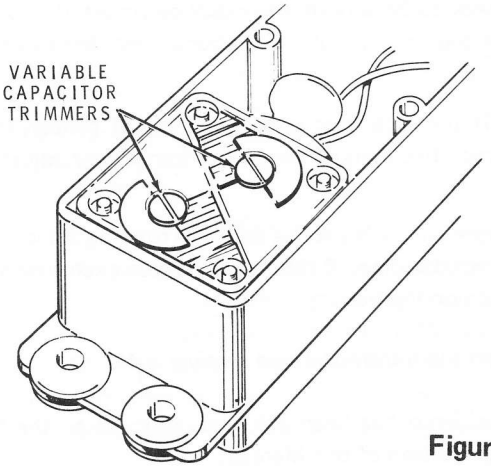


Figure 5

TRAVEL

( ) Remove both linear output arms.

( ) Turn the transmitter and receiver on.

( ) Move the channel #1 trim tab to one end and then the other while operating its stick through its entire range. Check to be sure that the rack gear posts do not touch the ends of the slots of the Servo case. See Figure 6.

NOTE: If the rack gear post travel is not proper, refer to your transmitter manual for proper transmitter adjustments.

( ) Check the Servo to be sure it is running smoothly and is not binding. Binding will cause excessive current drain on the battery.

( ) Turn the transmitter and receiver off.

When the Servo has been adjusted, proceed to the "Final Assembly" section of this Manual.

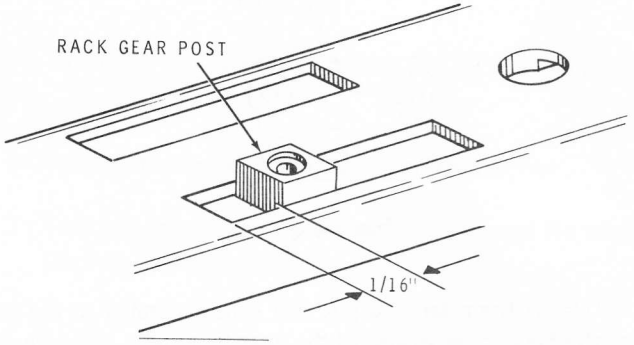


Figure 6

Troubleshooting Chart

CONDITION	POSSIBLE CAUSE
Servo completely dead. Motor will not turn in either direction.	1. Faulty connection between receiver and Servo. 2. Receiver battery run down. 3. Servo transistors Q8 and Q9 interchanged. 4. Servo transistors Q4 through Q9. 5. Faulty component in one of the above stages.
Servo motor runs when the transmitter is turned off.	1. Faulty positive (red wire) connection between receiver and Servo. 2. Capacitor C5. 3. Transistors Q1 through Q9.
Servo motor runs only in a clockwise direction, when viewed from shaft end.	1. Servo transistors Q5, Q7, or Q9. 2. Control housing lever misadjusted in transmitter.
Servo motor runs only in a counterclockwise direction, when viewed from shaft end.	1. Servo transistors Q4, Q6, or Q8. 2. Control housing lever misadjusted in transmitter.

Check the equipment to see that all parts and screws are in place. (Do not include wooden cabinets when shipping receivers, tuners, amplifiers, or TV sets, as these are easily damaged in shipment.) Then, wrap the equipment in heavy paper. Place the equipment in a strong carton, and put at least THREE INCHES of resilient packing material (shredded paper, excelsior, etc.) on all sides, between the equipment and the carton. Seal the carton with gummed paper tape, and tie it with a strong cord. Ship it by prepaid express, United Parcel Service, or insured parcel post to:

Heath Company
Service Department
Benton Harbor, Michigan 49022

SPECIFICATIONS

Input Signal	Pulse: 1 to 2 milliseconds wide; 4 volts peak-to-peak.
Thrust	3.25 lbs. minimum.
Transit Time for 5/8" Travel	0.7 seconds.
Linear Output Travel	5/8" end-to-end.
Rotary Output Travel	Over 100 degrees rotation (end-to-end).
Temperature Range	0 degrees to +160 degrees F.

Power (Battery) Requirements	Idling Current: 2 mA. Stall Current: 350 mA. No Load Running Current: 80 mA typical.
Total Gear Train Backlash	Less than .002".
Mechanical Output	1 – rotary arm. 1 – rotary wheel 2 – linear arms.
Position Accuracy	±0.5%.
Dimensions	1-3/4" high x 15/16" wide x 3-1/16" long. (Length includes mounting ears. Height includes linear arms.)
Net Weight	2.5 oz.

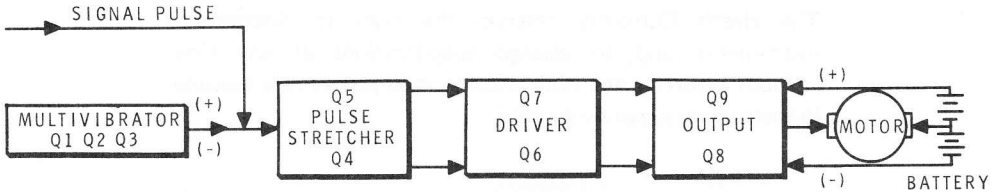
The Heath Company reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to incorporate new features in instruments previously sold.

CIRCUIT DESCRIPTION

The Servo unit translates the pulses that come from the Receiver into positive or negative voltages, and these voltages operate a motor that moves a control surface of a model. The signal pulses and the battery voltages are coupled from the receiver to the Servo through a multi-pin connector. The miniature circuit board in the Servo contains a monostable multivibrator circuit, a pulse stretcher circuit, a driver circuit, and an output circuit. Each of these circuits will be described separately in the following paragraphs. Refer to the Block Diagram and to the Schematic Diagram (fold-out from Page 47) while you read this "Circuit Description."

MULTIVIBRATOR CIRCUIT

Transistors Q1, Q2 and Q3 form a monostable (one-shot) multivibrator. See Figure 8. In this multivibrator circuit, transistors Q1 and Q2 normally conduct while Q3 is normally cut off. When a positive signal pulse from the receiver is applied through R8 and R9 to the collector circuit of Q3, the conditions are reversed and Q3 conducts while Q1 and Q2 are cut off. The circuit remains in the reversed condition for a definite period of time and then returns to the normal condition.



BLOCK DIAGRAM

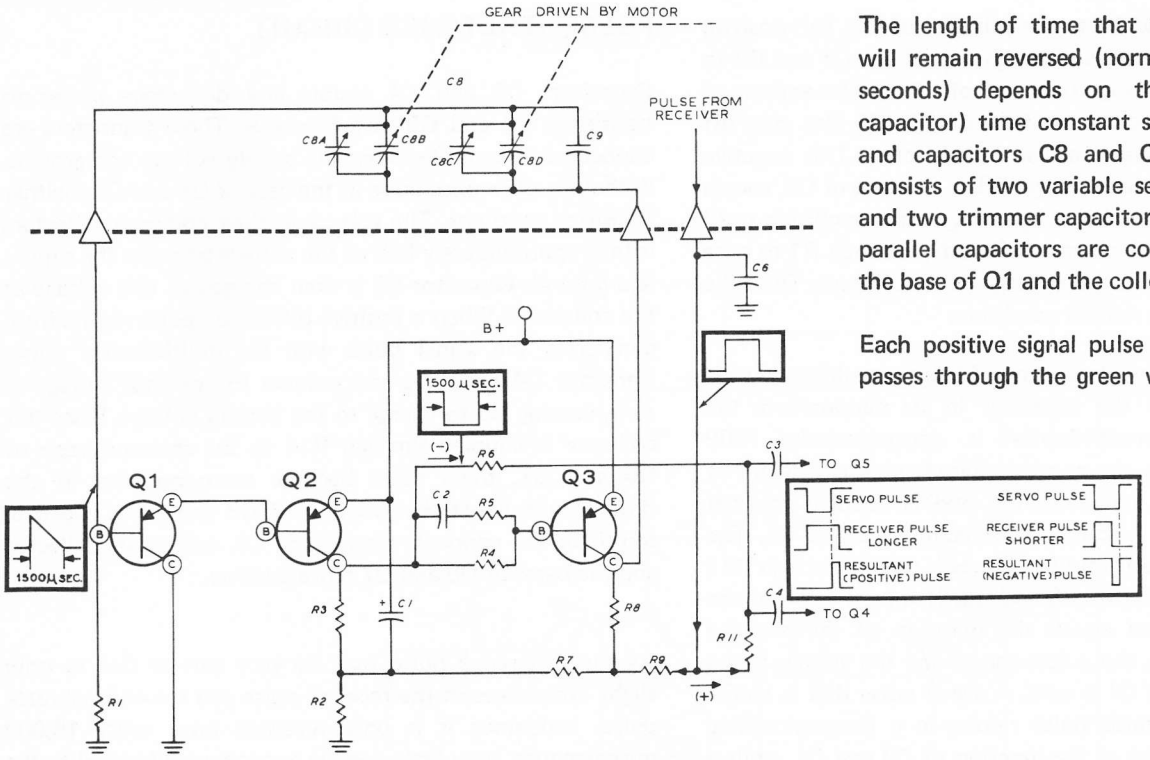


Figure 8

MONOSTABLE MULTIVIBRATOR

The length of time that the multivibrator will remain reversed (normally 1500 microseconds) depends on the RC (resistor-capacitor) time constant set by resistor R1 and capacitors C8 and C9. Capacitor C8 consists of two variable sections, B and D, and two trimmer capacitors, A and C. These parallel capacitors are connected between the base of Q1 and the collector of Q3.

Each positive signal pulse from the receiver passes through the green wire of the Servo

and resistors R9 and R8 to the collector of Q3. This positive signal voltage also passes through capacitors C8 and C9 to the base of Q1, causing Q1 to cut off. Since the emitter of Q1 is direct-coupled to the base of Q2, Q2 also cuts off producing a negative pulse at its collector. This negative pulse, which is coupled through R4 to the base of Q3, causes Q3 to conduct. The circuit remains in this condition until capacitors C8 and C9 charge sufficiently through R1 to raise the base voltage of Q1 and cause it to conduct. Then the circuit reverts to its normal condition.

The variable sections of capacitor C8 are gear-driven by the servo motor. With the capacitor in its midposition, the period of the multivibrator is approximately 1500 microseconds. Thus, the negative pulse from the collector of Q2 lasts for 1500 microseconds, and is coupled through resistor R6 to the junction of capacitors C3 and C4. The positive signal pulse from the receiver is passed through R11 to the same junction of C3 and C4. If the duration of the positive signal pulse equals the duration of the negative multivibrator pulse, the pulses cancel and the voltage at the junction of C3 and C4 is zero. A signal pulse that is longer than the multivibrator pulse results in a proportionately positive voltage pulse at the junction of C3 and C4, while a shorter signal pulse leaves a proportionately negative voltage pulse at this junction.

PULSE STRETCHER CIRCUIT

Capacitors C3 and C4 couple any difference pulses to transistors Q4 and Q5. See Figure 9. These transistors are connected in series between the supply voltage and ground. Without a difference pulse at the base of Q4 and Q5, neither transistor conducts. The voltage at their common collectors is then approximately half of the voltage between the supply and ground. Capacitor C5 is then charged to this voltage at the collectors. When a positive difference pulse results from comparing the signal pulse with the multivibrator pulse, transistor Q4 conducts and reduces its collector voltage to zero, causing C5 to charge to the battery voltage. Since this collector is coupled through R14 to the common bases of Q6 and Q7, these bases become more negative. If the difference pulse at the junction of C3 and C4 is negative, transistor Q5 conducts discharging C5, making its collector and the bases of Q6 and Q7 more positive.

As the difference pulse may be very narrow due to only slight differences in the receiver pulse and the multivibrator pulse, and since it is only repeated once every 16,000 microseconds, very little average current would be fed to the motor. Therefore, C5 is used to stretch out this pulse at the collectors of Q4 and Q5 to hold this voltage there for a

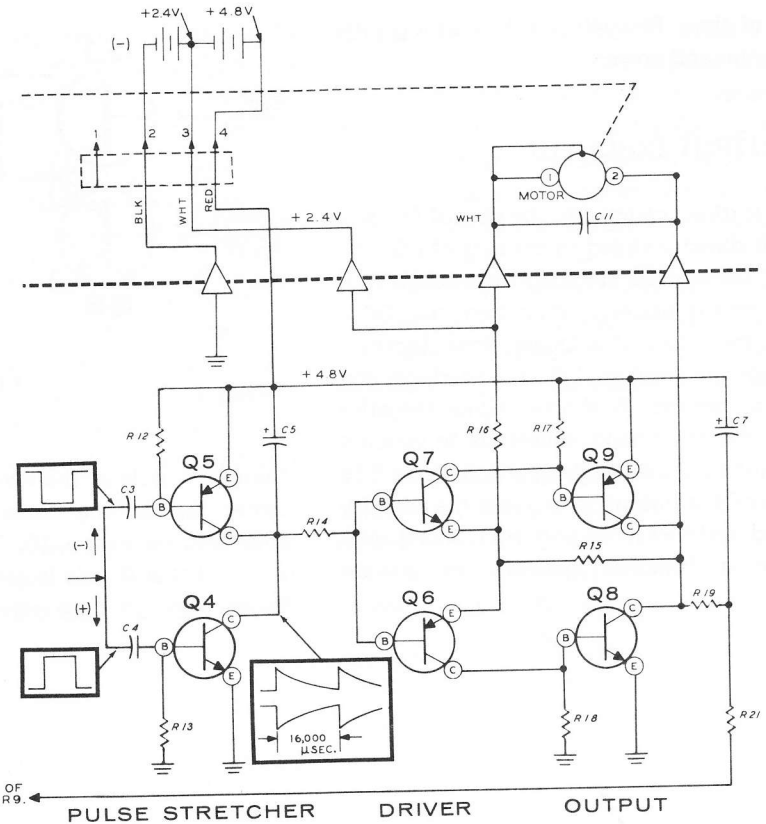

+2.4V
+4.8V
(-)
1
2
3
4
BLK
WHT
RED
+2.4V
WHT
MOTOR
C11
+4.8V
R12
C5
R16
R17
C7
Q5
Q7
Q9
C3
R14
R15
(-)
(+)
Q4
Q6
Q8
R19
C4
R13
16,000 µSEC.
R18
R21
TO JUNCTION OF R7, R8, AND R9.
PULSE STRETCHER
DRIVER
OUTPUT

Figure 9

much longer period of time. This will give the motor greatly increased average current and power.

DRIVER AND OUTPUT CIRCUITS

The collector of Q6 is direct coupled to the base of Q8, and the collector of Q7 is direct coupled to the base of Q9. The common emitters of Q6 and Q7 are supplied through R16 from the center tap of the battery. When transistor Q6 is made to conduct as the result of a longer signal (positive difference) pulse from the receiver, Q8 also conducts and shorts its collector to ground. A shorter signal (negative difference) pulse, on the other hand, causes Q9 to conduct and shunts its collector to the 4.8 volt supply. Resistor R15 feeds back a portion of the output to increase the stability of the amplifier, and resistors R19 and R21, along with capacitor C7, form a feedback network to prevent overshoot.

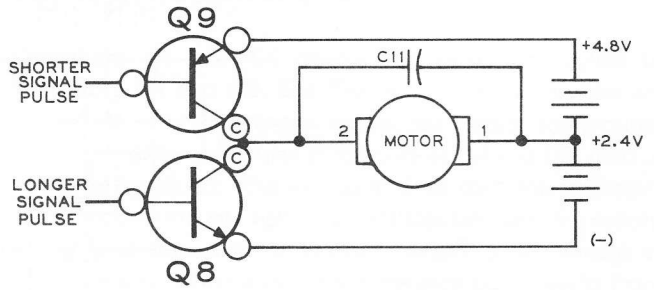


Figure 10

Number 1 pole of the reversible motor is connected to the center tap of the battery as shown in the simplified schematic of Figure 10. The motor runs in one direction when number 2 pole is connected to the positive end of the battery, and reverses when this pole is connected to the

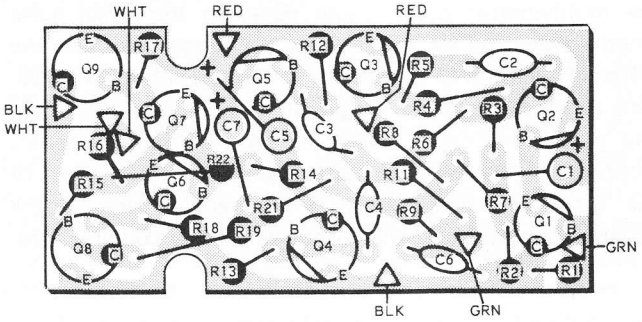
negative (ground) end of the battery. Transistors Q6 and Q7 are the drivers that operate Q8 and Q9 to perform the battery switching that drives the motor.

The collectors of Q8 and Q9 are common to the number 2 pole of the motor. With a signal pulse from the receiver that is longer than the multivibrator pulse, transistors Q4, Q6, and Q8 conduct, making the number 2 pole of the motor negative, and driving the motor in one direction. When the signal pulse from the receiver is shorter than the multivibrator pulse, transistors Q5, Q7, and Q9 conduct. This places the number 2 pole of the motor at the positive end of the battery supply, and the motor runs in the opposite direction. Capacitor C11 is used to filter out motor brush noise.

The length of the multivibrator period is determined by the RC time constant of resistor R1 and variable capacitors C8 and C9. The rotor plates of C8B and C8D are gear-driven by rotation of the servo motor. When a signal pulse length differs from the multivibrator pulse length, the motor turns in one direction and rotates the variable capacitor plates. When the capacity of C8B and C8D change enough to make the multivibrator pulse length equal to the signal pulse length, these pulses cancel and no longer produce the difference pulse that is required to turn on either Q4 or Q5. This absence of a pulse length difference keeps the driver and output transistors turned off and the motor remains stopped. In this way, each difference pulse length input to the Servo is represented by a different portion of the variable capacitor and the output wheel and coupling tabs.

The motor gear train turns the variable capacitor rotor plates while it drives a pair of rack gears. The rack gears can be driven approximately 5/8". These rack gears are mechanically connected to one of the control devices in the model so that the Servo unit operates the device.

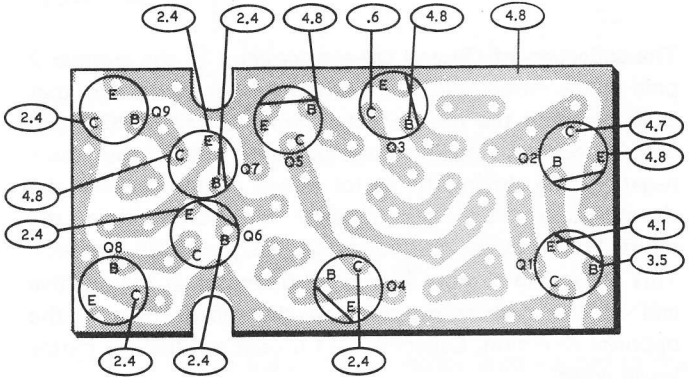
X-RAY VIEW



CIRCUIT BOARD

(SHOWN FROM FOIL SIDE)

VOLTAGE CHART



CIRCUIT BOARD

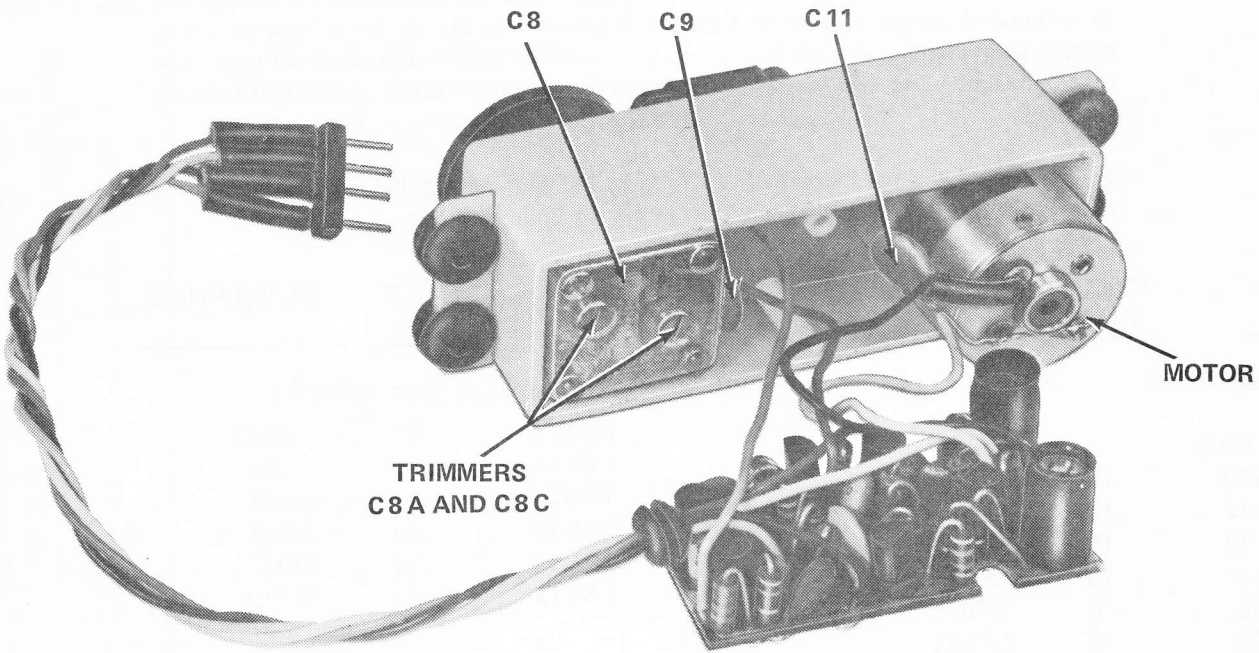
(SHOWN FROM FOIL SIDE)

+DC VOLTAGE

NOTE: To identify a part shown in one of these Views, so you can order a replacement, proceed as follows:

1. Note the identification number of the part (R-number, C-number, etc.).
2. Locate the same identification number (next to the part) on the Schematic. The "Description" of the part (22 kΩ, .05 μF, 2N3712) will also appear near the part.
3. Look up this description in the "Replacement Parts Price List."

CHASSIS PHOTOGRAPH



SCHEMATIC OF THE HEATHKIT®
DIGITAL PROPORTIONAL SERVO
MODEL GDA-19-4

1. ALL RESISTORS ARE 1/4 WATT.
   RESISTOR VALUES ARE IN OHMS (K = 1,000, MEG = 1,000,000).

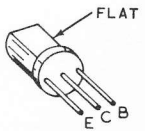
2. ALL CAPACITOR VALUES ARE IN μF UNLESS MARKED OTHERWISE.

3. ⬭ THIS SYMBOL INDICATES A POSITIVE DC VOLTAGE MEASUREMENT WITH NO SIGNAL BEING RECEIVED.

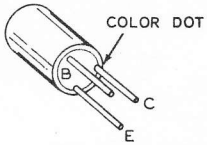
4. ALL VOLTAGES ARE MEASURED WITH A HIGH IMPEDANCE VOLTMETER, FROM THE POINT INDICATED TO COMMON GROUND. VOLTAGES MAY VARY ±20%.

5. REFER TO THE SERVO PHOTOGRAPHS AND CIRCUIT BOARD X-RAY VIEW FOR THE PHYSICAL LOCATION OF PARTS.

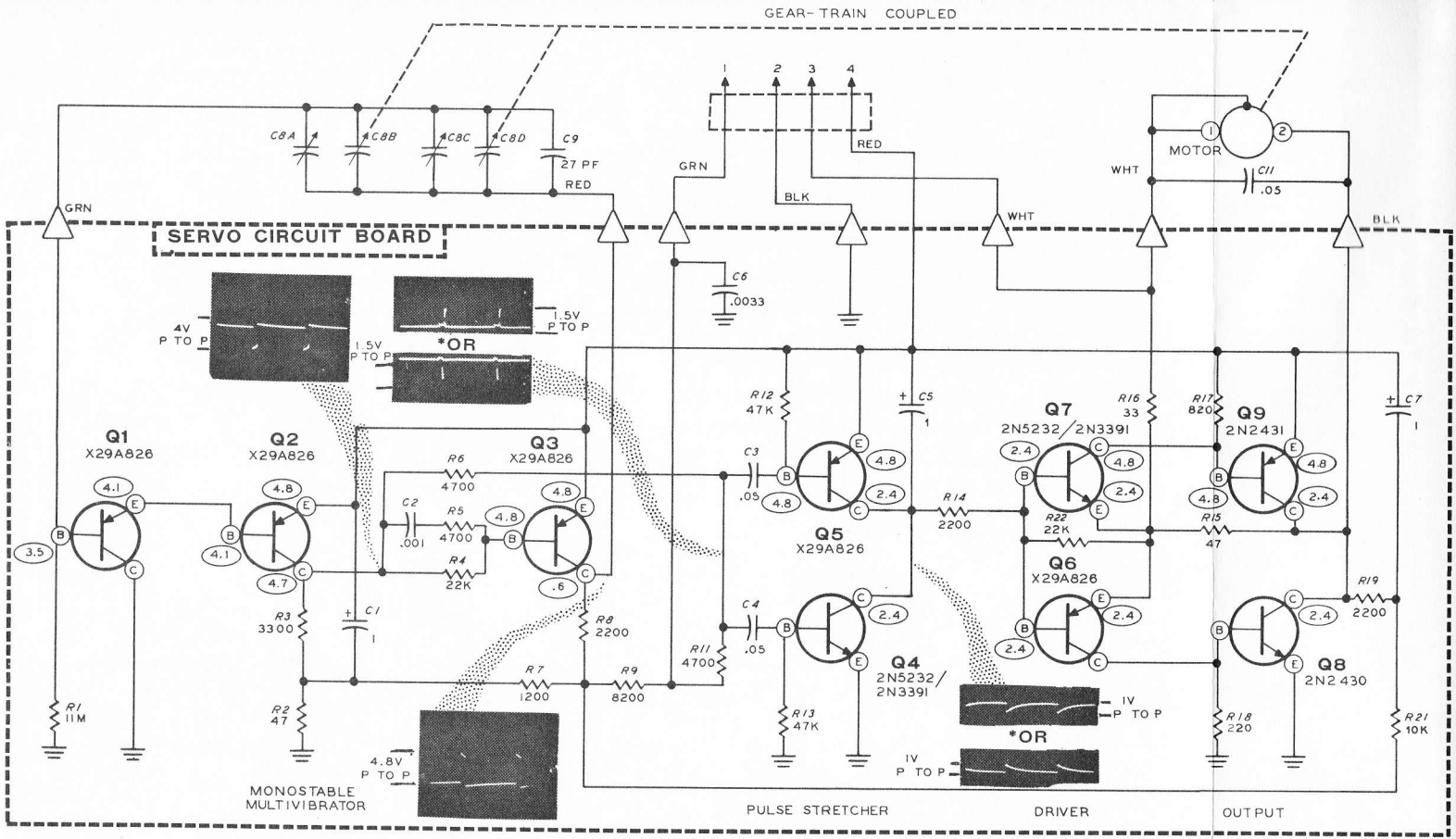
6. ✳ THESE WAVEFORMS SHOW THE DRIVE SIGNALS FOR BOTH DIRECTIONS.



2N5232/2N3391
X29A826



2N2430
2N2431


GEAR-TRAIN COUPLED
C8A
C8B
C8C
C8D
C9
27 PF
RED
GRN
1
2
3
4
RED
GRN
BLK
WHT
MOTOR
C11
.05
WHT
BLK
SERVO CIRCUIT BOARD
C6
.0033
4V
P TO P
1.5V
P TO P
*OR
1.5V
P TO P
R12
47K
C5
1
Q7
2N5232/2N3391
R16
33
R17
820
Q9
2N2431
C7
1
Q1
X29A826
Q2
X29A826
Q3
X29A826
R6
4700
C3
.05
R14
2200
R22
22K
R15
47
Q5
X29A826
Q6
X29A826
C2
.001
R5
4700
R4
22K
C1
1
R8
2200
C4
.05
R11
4700
R19
2200
R3
3300
R7
1200
R9
8200
Q4
2N5232/
2N3391
Q8
2N2430
R1
11M
R2
47
R13
47K
IV
P TO P
*OR
IV
P TO P
R18
220
R21
10K
4.8V
P TO P
MONOSTABLE
MULTIVIBRATOR
PULSE STRETCHER
DRIVER
OUTPUT