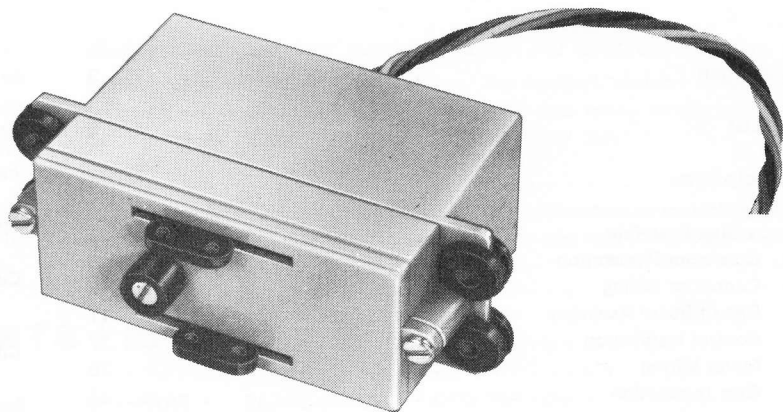


Assembly and Operation
of the



MINIATURE DIGITAL PROPORTIONAL SERVO

MODEL GDA-19-41
and
MODEL GDA-405-4



HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022

INTRODUCTION

The Heathkit Model GDA-19-41 or Model GDA-405-4 Miniature Digital Proportional Servo is a compact, electromechanical unit that is used to accurately move the control elements in model airplanes, boats, and cars. Both linear-motion outputs travel in opposite directions from each other, providing a more universal servo. The Servo can also be converted to use rotor outputs.

This Servo has been designed for long life and trouble-free operation. An integrated circuit provides a stable and accurate output and takes the place of

seven transistors and their associated resistors and capacitors. Therefore, the Servo is very small, light, and compact. The feedback element consists of a ceramic variable control. The Servo, including glass epoxy circuit board and nylon gears, is housed in a compact molded nylon case.

Refer to the "Kit Builders Guide" for complete information on unpacking, parts identification, tools, wiring, soldering, and step-by-step assembly procedures.

PARTS LIST

NOTE: This assembly Manual contains instructions for both the GDA-19-41 and GDA-405-4 Servos. Some parts will be found only in one Model and not in the other. These parts are indicated as such in the following list.

Check each part against the following list. The key numbers correspond to the Parts Pictorial (fold-out from Page 7).

To order replacement parts, refer to the "Price Each" column and use the Parts Order Form furnished with this kit. If a Parts Order Form is not available, refer to "Replacement Parts" in the "Kit Builders Guide."

KEY PART		PARTS	PRICE	DESCRIPTION
No.	No.	Per Kit	Each	

RESISTORS

1/4 Watt

A1	1-4-12	1	.10	2200 Ω (red-red-red)
A1	1-28-12	1	.10	8200 Ω (gray-red-red)
A1	1-94-12	1	.10	18 k Ω (brown-gray-orange)
A1	1-16-12	2	.10	180 k Ω (brown-gray-yellow)
A1	1-38-12	2	.10	220 k Ω (red-red-yellow)
A1	1-93-12	2	.10	330 k Ω (orange-orange-yellow)

KEY PART No.	PARTS No.	PRICE Per Kit	PRICE Each	DESCRIPTION
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Model GDA-405-4 only:

A2	1-99-12	1	.10	1800 Ω (brown-gray-red)
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Precision

A2	2-20-11	1	.40	14.3 k Ω
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CAPACITORS

B1	21-94	1	.45	.05 μ F disc
B2	21-175	1	.45	.001 μ F ceramic (brown-black-red)
B3	25-211	2	.85	33 μ F tantalum
B3	25-255	1	1.10	.22 μ F tantalum (R22 μ F)
B3	25-256	2	.60	.47 μ F tantalum (R47 μ F)

TRANSISTORS-INTEGRATED CIRCUIT-DIODES

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

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

KEY PART No.	PARTS No.	PRICE Per Kit	PRICE Each	DESCRIPTION
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Transistors-Integrated Circuit-Diodes (cont'd.)

C1	417-267	1	.65	MPS6560 transistor
C1	417-268	1	.70	MPS6562 transistor
C2	443-75	1	5.50	Integrated circuit
C3	56-56	2	.20	1N4149 silicon diode
C4	56-74	1	.65	MZ2362 compensating diode

WIRE-SLEEVING

NOTE: For wire and sleeving, the price is per foot.

340-3	1	.05	Bare wire
344-125	1	.05	Black wire
344-127	1	.05	Red wire
344-130	1	.05	Green wire
344-134	1	.05	White wire (Model GDA-19-41 only)
346-1	1	.05	Sleeving

KEY PART No	PARTS No	PRICE Per Kit	PRICE Each	DESCRIPTION
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HARDWARE

D1	250-547	2	.05	0-80 x 1/4" black screw
D2	250-1123	4	.05	1-72 x 1/8" screw (one extra)
D3	250-467	2	.05	2-56 x 3/16" binder head screw
D4	250-537	2	.05	2-56 x 3/16" flat head screw
D5	250-82	4	.05	#4 x 1/2" woodscrew
D6	238-1	1	.10	3/8" gear pin
D6	238-2	1	.10	1/4" gear pin
D7	238-16	1	.45	Control drive shaft

MOLDED NYLON PARTS

E1	238-3	1	.75	Right rack gear
E2	238-4	1	.75	Left rack gear
E3	238-5	1	.45	Rotary drive gear
E4	238-6	1	.45	Rack drive gear
E5	238-7	1	.45	Idler gear
E6	238-8	1	.45	Motor coupling gear
E7	238-9	1	.30	Rotary output wheel
E8	238-10	1	.30	Rotary output arm
E9	238-12	1	1.30	Case bottom section
E10	238-13	1	1.65	Case center section
E11	238-14	1	.75	Rotary case top section
E12	238-15	1	.75	Rack case top section
E13	238-17	1	.30	Rotor cap

KEY PART No	PARTS No	PRICE Per Kit	PRICE Each	DESCRIPTION
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MISCELLANEOUS

F1	9-40	1	1.65	1500 Ω control
F2	73-59	4	.10	Large rubber grommet
F2	73-53	1	.10	Small rubber grommet
	85-510	1	.25	Circuit board
F3	238-11	1	.75	Control wiper
F4	420-73	1	5.00	Motor
F5	432-104	1	.70	4-pin male connector (GDA-19-41 only)
F6	238-32	1	1.45	4-pin male connector assembly (GDA-405-4 only)
	391-34	1		Blue and white label
	597-260	1		Parts Order Form
	597-308	1		Kit Builders Guide
		1	2.00	Manual (See front cover for part number.)
				Solder (Additional 3' rolls of solder, #331-6, can be ordered for 15 cents each.)

The above prices apply only on purchases from the Heath Company where shipment is to a U.S.A. destination. Add 10% (minimum 25 cents) to the price when ordering from a Heathkit Electronic Center to cover local sales tax, postage, and handling. Outside the U.S.A. parts and service are available from your local Heathkit source and will reflect additional transportation, taxes, duties, and rates of exchange.

TEST AND ADJUSTMENTS

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 in your transmitter Manual.

If the Servo does not operate as described, refer to the "In Case of Difficulty" section on Page 30.

CENTERING

Refer to Figure 4 (fold-out from this page) 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 may start to run and then stop. This is normal.
- () Move the transmitter channel #1 stick in one direction and then the other. The Servo should move, stop, and reverse direction according to the stick position.
- () Release the stick.

Refer to Figure 5 for the following steps.

NOTE: If the rack gears are straight across from each other as shown, disregard the following step. Proceed to the "Travel" section.

() Adjust the control drive shaft in the rotary output post, with a small screwdriver, until the rack gears are parallel with each other.

NOTE: As you turn the shaft, the rotary output post will turn in the opposite direction. It may be necessary to repeat this adjustment several times to get the rack gears properly positioned.

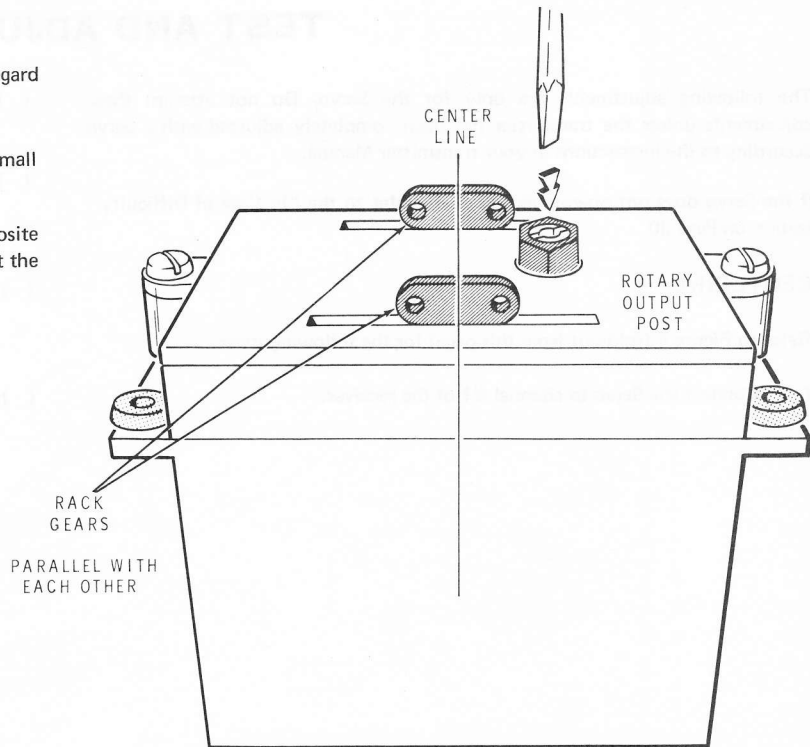


Figure 5

TRAVEL

Refer to Figure 6 for the following steps.

- () Move the transmitter 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 center line on the rack gears does not exceed the center line of the rotary output post.

NOTE: If the rack gear 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.
- () To ensure proper operation of the servo, a 2 to 5 minute break-in period is recommended. Use your system to run the Servo from end-to-end.
- () Turn the transmitter and receiver off.

This completes the "Test and Adjustments" section. Proceed to the "Final Assembly" section.

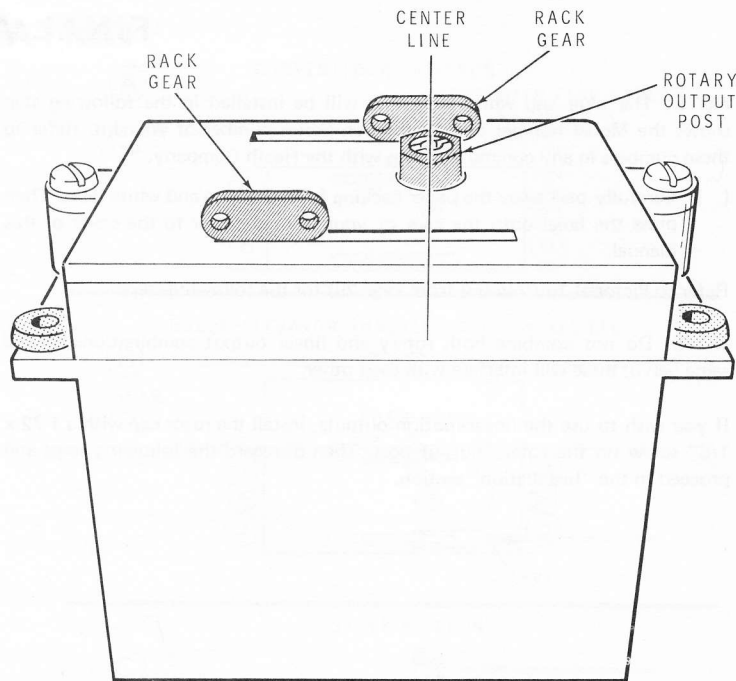


Figure 6

Troubleshooting Chart

CONDITION	POSSIBLE CAUSE
Servo completely dead.	<ol style="list-style-type: none"> 1. Dead battery. 2. Faulty connections or miswired servo connector. 3. Transistors Q1 and Q2 interchanged or installed backwards. 4. Solder or wire bridges around the leads of the IC. 5. Check for proper component installation.
Servo travels to one end and stays there.	<ol style="list-style-type: none"> 1. Transistor Q1 or Q2. 2. Control R7 wired wrong. 3. Motor wired wrong. 4. Resistors R2 and R3.

CONDITION	POSSIBLE CAUSE
Servo operates in only one direction.	<ol style="list-style-type: none"><li data-bbox="857 197 1101 218">1. Transistor Q1 or Q2.<li data-bbox="857 249 1117 270">2. Capacitors C1 and C2.<li data-bbox="857 301 1101 322">3. Resistors R2 and R3.
Servo unstable (hunts or chatters).	<ol style="list-style-type: none"><li data-bbox="857 356 1154 377">1. Capacitors C3, C5, and C6.<li data-bbox="857 408 1149 428">2. Resistors R1, R5, and R6.
Servo slow (sluggish) low power.	<ol style="list-style-type: none"><li data-bbox="857 459 1045 480">1. The gear train.<li data-bbox="857 511 1040 532">2. Weak battery.<li data-bbox="857 563 1110 584">3. Diode D1, D2, or D3.<li data-bbox="857 615 1029 636">4. Resistor R4.

NOTE: The IC has been pretested and should not be an initial source of a problem. However a defective IC can cause any of the above conditions.

SPECIFICATIONS

Input Signal	Pulse: 1-2 msec. wide: 4 volts, p-p.
Thrust	4 lbs. minimum at racks and rotor.
Travel Time	0.6 seconds.
Linear Output Travel	1/2" end-to-end.
Rotary Output Travel	90 degrees rotation.
Temperature Range	0 degrees to +160 degrees F.
Power Requirements	Battery: 4.8 V CT. Idle Current: 10 mA maximum. Stall Current: 600 mA nominal. No Load Current: 80 mA.
Gear Train Backlash	Less than .022".
Mechanical Output	1 rotary arm. 1 rotary wheel. 2 linear racks.
Position Accuracy	1.0%.
Dimensions	1-5/8" high x 7/8" wide x 2-17/32" long (length includes mounting ears. Height includes the outputs).
Net Weight	1.75 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 width of the 4-volt pulses from the receiver controls the position of the servo outputs. Widening these pulses, drives the servo gear-train in one direction, and narrowing the pulses, drives the servo gear-train in the other direction. The pulse widths are variable from one to two milliseconds, and are controlled by a transmitter stick control. Therefore, moving a transmitter stick changes the pulse width, which in turn causes the servo gear-train to move.

Refer to the Schematic Diagram (fold-out from Page 37) while you read this "Circuit Description."

INPUT AND TIMING CIRCUITS

A positive input pulse is coupled from the receiver, through the servo connector, to pin 2 of the IC (integrated circuit), and through capacitor C4 to pin 1 of the IC. The pulse causes the IC to generate a negative reference pulse. The width of this reference pulse is controlled by feedback control R7, resistor R1, and capacitor C3.

The negative reference pulse is compared with the incoming positive pulse. If the incoming pulse is narrower than the reference pulse, then the difference between pulses is a small negative pulse that is inverted, shaped, and used to drive transistor Q2. However, if the incoming pulse is wider than the reference pulse, then the difference between pulses is a small positive pulse that is inverted, shaped, and used to drive transistor Q1.

Transistor Q1 drives the motor in one direction and transistor Q2 drives the motor in the other direction. The motor then turns the feedback control until the negative reference pulse is the same width as the positive incoming pulse. The pulses then cancel out and the motor stops. Resistor R5 couples the voltage from control R7 to pin 6 of the IC.

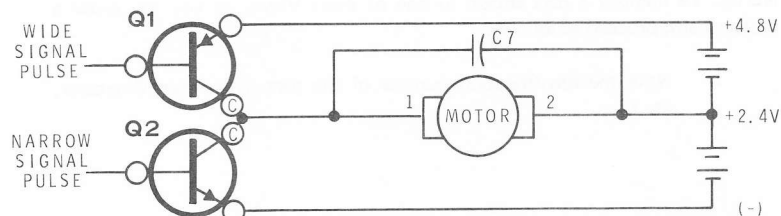


Figure 8

DRIVE CIRCUITS

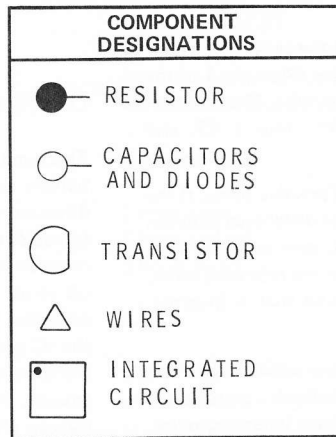
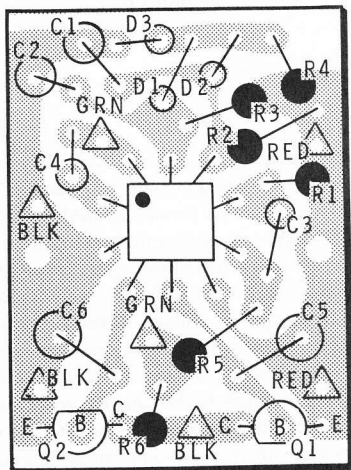
The number 2 pole of the reversible motor is connected to the center tap of the battery as shown in the simplified schematic of Figure 8. The motor runs in one direction when the number 1 pole is connected to the positive end of the battery (through transistor Q1) and reverses direction when this pole is connected to the negative (ground) end of the battery (through transistor Q2). Capacitors C5 and C6 round the sharp switching pulse at the bases of transistors Q1 and Q2 and capacitor C7 filters out motor brush noise. Resistors R2 and R3 provide bias for the IC and, along with capacitors C1 and C2, modify the pulse shape to control the drive of transistors Q1 and Q2. Diodes D1, D2, D3, and resistor R4 limit the amount of drive to the transistors by limiting the voltage that capacitors C1 and C2 can charge to. This prevents excessive drive of the transistors under large error conditions. Resistor R6 is a damping resistor which prevents the Servo from overshooting.

CIRCUIT BOARD X-RAY VIEW

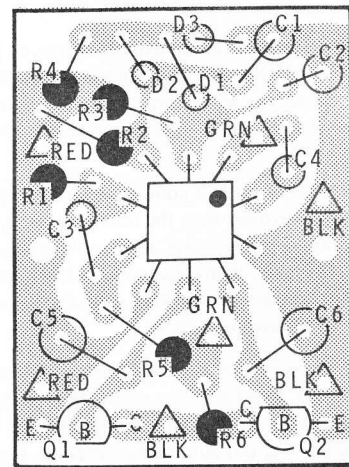
NOTE: To identify a part shown in one of these Views, so you can order a replacement, proceed as follows:

- Note the identification number of the part (R-number, C-number, etc.).
- Locate the same identification number (next to the part) on the Schematic. The "Description" of the part (for example: 330 k Ω , .47 μ F, or MPS6560) will also appear near the part.
- Look up this Description in the Parts List.






(VIEWED FROM FOIL SIDE)

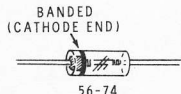
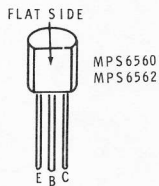
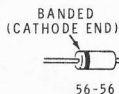


(VIEWED FROM COMPONENT SIDE)

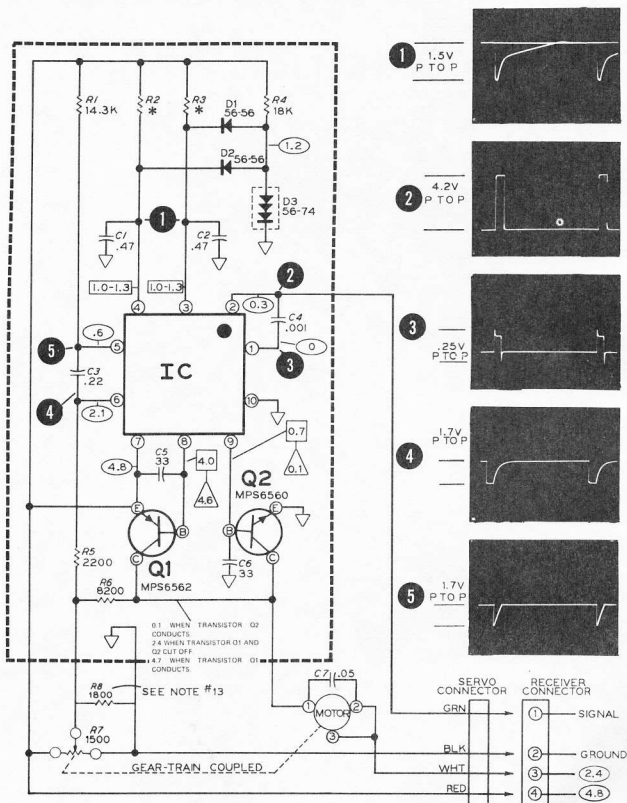


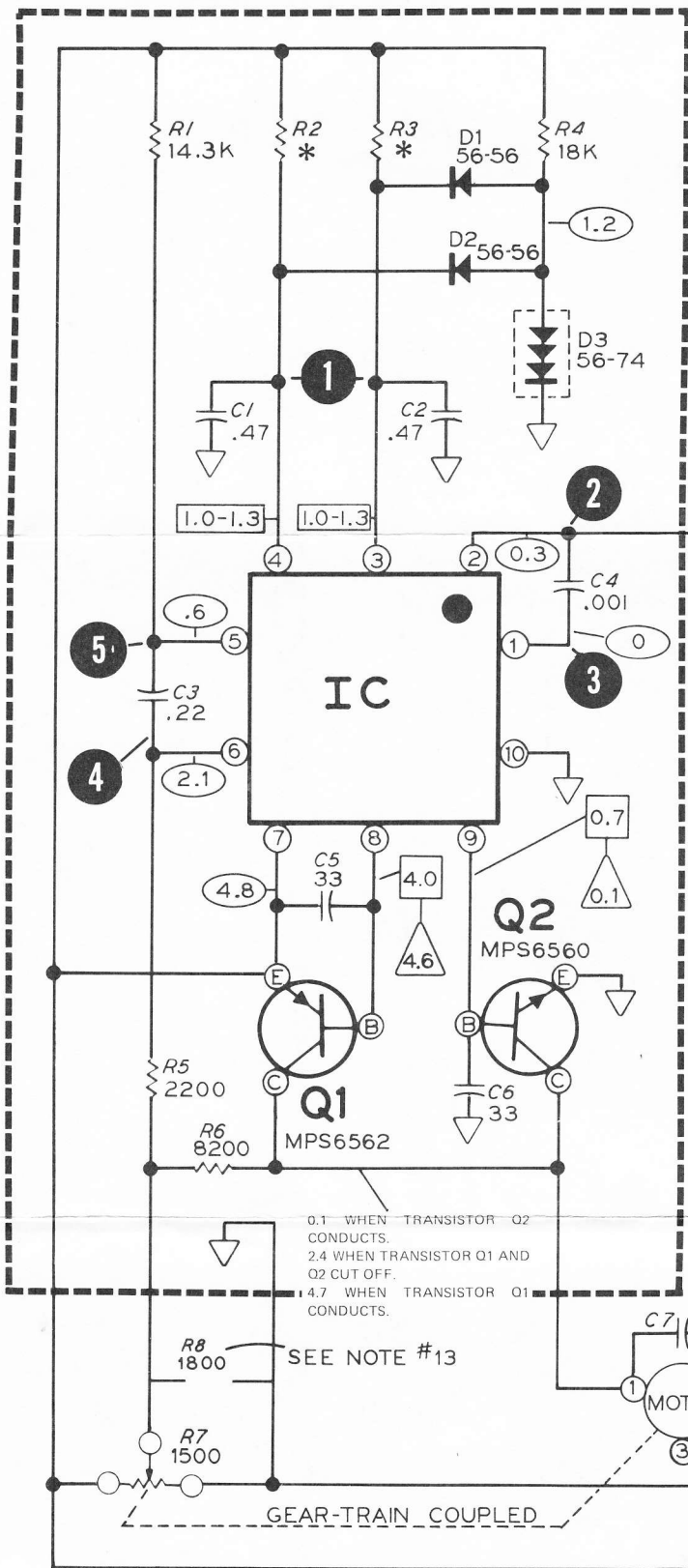
NOTES:

- ALL RESISTORS ARE 1/4 WATT. RESISTOR VALUES ARE IN OHMS (K=1000).
- ALL CAPACITOR VALUES ARE IN μF .
-  THIS SYMBOL INDICATES A POSITIVE DC VOLTAGE MEASUREMENT WITH NO SIGNAL BEING RECEIVED.
-  THIS SYMBOL INDICATES THE NORMAL OPERATING VOLTAGE RANGE.
-  THIS SYMBOL INDICATES ON VOLTAGE.
-  THIS SYMBOL INDICATES OFF VOLTAGE.
-  THIS SYMBOL INDICATES A WAVEFORM DISPLAY AT THE POINT INDICATED, AS SHOWN NEXT TO THE SCHEMATIC.
- VOLTAGE ON PIN 2 OF THE IC IS VARIABLE FROM 0.2 TO 0.4, DEPENDING ON THE INPUT PULSE.
- VOLTAGE ON PIN 6 OF THE IC IS VARIABLE FROM 1.5 TO 2.7, DEPENDING ON THE INPUT PULSE.
- ALL VOLTAGES ARE MEASURED WITH A HIGH IMPEDANCE VOLTMETER FROM THE POINT INDICATED TO COMMON GROUND. VOLTAGES MAY VARY $\pm 20\%$.
- REFER TO THE SERVO PHOTOGRAPH AND CIRCUIT BOARD X-RAY VIEW FOR THE PHYSICAL LOCATION OF PARTS.
- * THE VALUES OF R2 AND R3 DEPEND ON THE RATING OF THE INTEGRATED CIRCUIT (IC), WHICH IS EXPRESSED BY A COLOR DOT ON THE IC CASE.
 YELLOW DOT - 180K Ω
 GREEN DOT - 220K Ω
 BLUE DOT - 330K Ω
- R8 IS USED IN MODEL GDA-405-4 ONLY.

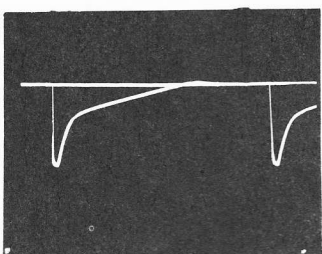


SCHEMATIC OF THE HEATHKIT[®] MINIATURE DIGITAL PROPORTIONAL SERVO MODEL GDA-19-41 AND GDA-405-4

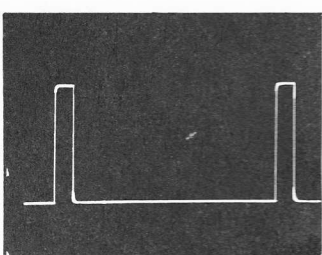




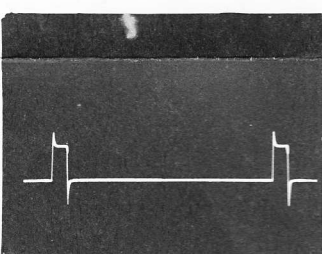
1 1.5V
P TOP



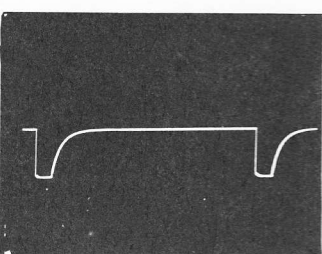
2 4.2V
P TOP



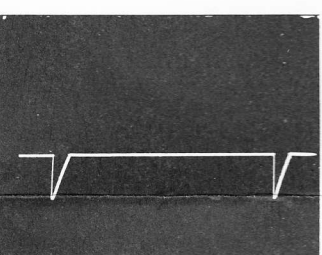
3 .25V
P TOP



4 1.7V
P TOP



5 1.7V
P TOP



0.1 WHEN TRANSISTOR Q2
CONDUCTS.
2.4 WHEN TRANSISTOR Q1 AND
Q2 CUT OFF.
4.7 WHEN TRANSISTOR Q1
CONDUCTS.

SEE NOTE #13

GEAR-TRAIN COUPLED

* THE VALUES OF R2 AND R3 DEPEND ON THE RATING OF THE INTEGRATED
CIRCUIT (IC), WHICH IS EXPRESSED BY A COLOR DOT ON THE IC CASE.

YELLOW DOT - 180KΩ
GREEN DOT - 220KΩ
BLUE DOT - 330KΩ

SCHMATIC OF THE HEATHKIT[®] MINIATURE DIGITAL PROPORTIONAL SERVO MODEL GDA-19-41 AND GDA-405-4